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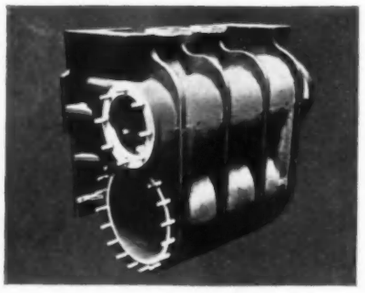

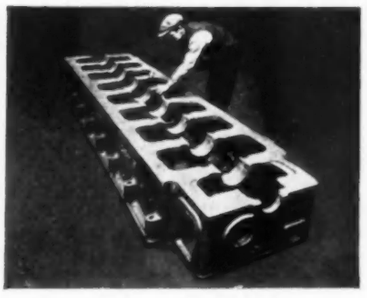

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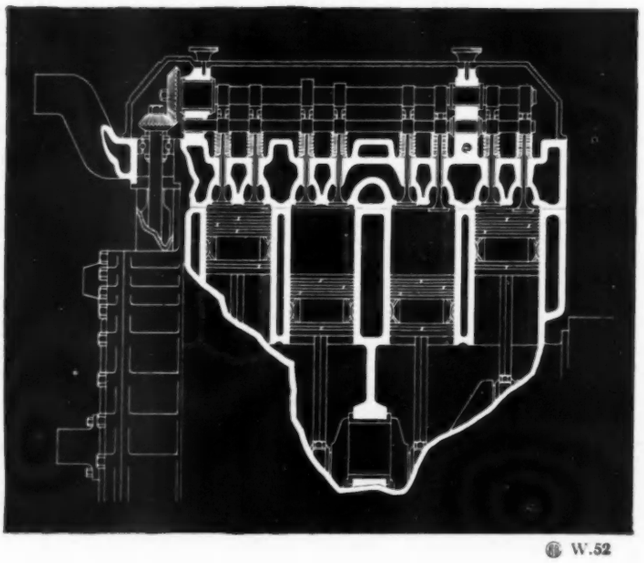

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41.

FLEXURE OF CONTINUOUS BEAMS AND BEAMS WITH FIXED ENDS.

By A. L. EGAN, A.M.I.Mech.E.

IN several text-books consulted by the writer, the net bending moments and deflections are obtained either by integration or by artifices such as considering the free bending moments (Fig. 1) as a load "to some scale." The scale is often troublesome to determine and the integration involves constants which are frequently elusive or even unobtainable. The method given below will solve the most complicated problem in a manner which is easy to understand and apply. It is based on the fact that an analysis of the slopes at the supports provides a simple and logical solution to beam problems. It is shown in any text-book on the subject that the sum of the slopes at the two ends of a freely supported beam is the area of the free bending moment (B.M.) diagram divided by EI. It is also shown in the text-books that, in order to fix one end horizontally or at any given angle, a moment tending to produce upward concavity must be applied round the end concerned. It is well known that such fixing or straightening moment is a cantilever moment having its maximum value at the end or support. The fixing or straightening moments will be referred to as pier moments or cantilever moments.

Consider the case of a continuous beam of two unequal spans each with any loading. Fig. 1 shows typical bending moment diagrams tending to produce downward concavity, and the four end slopes, if the beam is broken at the intermediate support and the ends are freely supported. Fig. 2 shows the deflected form when the beam is continuous (unbroken) and fixed at both ends. Fig. 2 also shows the pier moments required to fix the ends and to straighten out the beam at the intermediate support. The actual net bending moment at any point is the ordinate of the shaded areas of Fig. 2. The pier moments are M_A, M_B, and M_C (Fig. 3). The bending moments tending to produce upward concavity are the ordinates of the lines $a\,b$ and $b\,c$. The trapezium $a\,b$ B A on the span L can be divided by the line A b into two triangular areas which are readily identifiable as cantilever moments with maximum values M_A and M_B. Similarly on span l we have two cantilever moments M_B and M_C.

Each of the four cantilever moments tends to cause upward slopes at two supports which are opposed to the "free" slopes shown in Fig. 1, and these upward slopes are the key to the problem. The two hypothetical cantilevers M_B have a virtual fulcrum at the intermediate support and tend to produce the upward concavity shown in Fig. 4 and the upward slopes κ and μ. The cantilevers M_A and M_C produce the upward concavity shown in Fig. 5. The slope κ may conveniently be called the fulcrum slope and the slope μ the tip slope.

From any elementary text-book on cantilvers it can be deduced that the fulcrum slope

$$\kappa = \frac{\Delta}{L} = \frac{M\,L}{3\,E\,I} \quad . \quad . \quad . \quad (1)$$

and that the tip slope

$$\mu = \frac{M\,L}{6\,E\,I} \quad . \quad . \quad . \quad (2)$$

while

$$\kappa + \mu = \frac{M\,L}{2\,E\,I},$$

where M is the maximum bending moment. Thus κ and μ are easily found for each of the four cantilevers the moments of which are shown in Fig. 3, by inserting the appropriate symbols for M and L in equations (1) and (2). M_C has its virtual fulcrum at C and M_A at A. At A the upward slopes are the fulcrum slope κ of M_A plus the tip slope μ of M_B on L. At B the upward slopes are the tip slope μ of M_A plus the fulcrum slope κ of M_B on L plus the fulcrum slope κ of M_B on l plus the tip slope of M_C on l. At C, the upward slopes are the tip slope of M_B on l plus the fulcrum slope of M_C.

The opposed downward slopes β, θ, ϕ, ψ, Fig. 1, are obtained from the area of the free bending moment diagrams in a manner to be discussed later. The actual or net slope at A, B and C will be the algebraical difference of the upward and downward slopes, thus—

At A the actual slope is

$$\frac{M_A\,L}{3\,E\,I} + \frac{M_B\,L}{6\,E\,I} - \beta. \quad . \quad . \quad (3)$$

At B the actual slope is

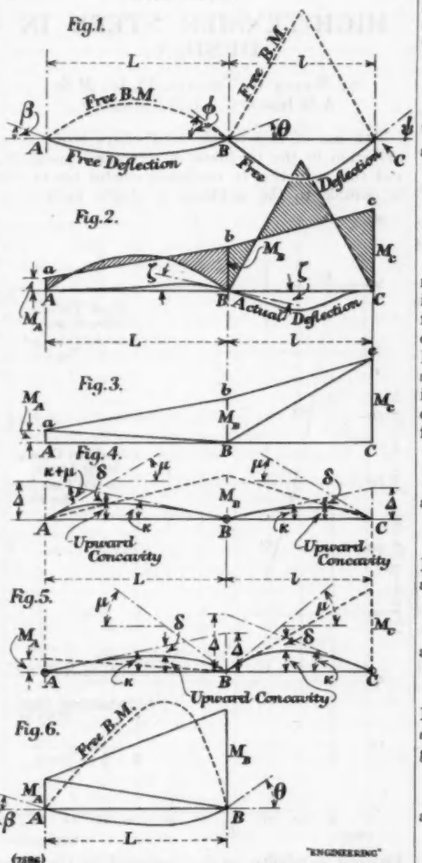
$$\frac{M_A\,L}{6\,E\,I} + \frac{M_B\,L}{3\,E\,I} - \theta. \quad . \quad . \quad (4)$$

At B the actual slope is also

$$\frac{M\,l}{6\,E\,I} + \frac{M_B\,l}{3\,E\,I} - \phi. \quad . \quad . \quad (5)$$

At C the actual slope is

$$\frac{M_C\,l}{3\,E\,I} + \frac{M_B\,l}{6\,E\,I} - \psi. \quad . \quad . \quad (6)$$



The two values of the actual slopes at B must be equal (see Fig. 2), but are of opposite sign, so

$$\frac{M_B\,L}{3\,E\,I} + \frac{M_A\,L}{6\,E\,I} - \theta = -\frac{M_A\,l}{3\,E\,I} - \frac{M_C\,l}{6\,E\,I} + \phi$$

from which

$$2\,M_B\,(L + l) + M_A\,L + M_C\,l = 6(\theta + \phi)E\,I \quad . \quad (7)$$

which is the general equation of three moments for two spans, arrived at by simple means without integration.

If the ends A and C are merely supported, then M_A and M_C are zero in equation (7) and we have

$$M_B\,(\text{free ends}) = \frac{3(\theta + \phi)\,E\,I}{L + l} \quad . \quad (8)$$

If the ends A and C are fixed, then the actual slope is zero at A and C, and from equations (3) and (6) we find

$$M_A\,L = 3\,E\,I\,\beta - \tfrac{1}{2}\,M_B\,L \quad . \quad . \quad (9)$$

$$M_C\,l = 3\,E\,I\,\psi - \tfrac{1}{2}\,M_B\,l. \quad . \quad . \quad (10)$$

Substituting these values of M_A and M_C in equation (7) gives

$$M_B\,(\text{fixed ends}) = \frac{2\,E\,I}{3(L + l)}\left\{6\,(\theta + \phi) - 3(\beta + \psi)\right\} \quad (11)$$

which gives the value of M_B when both ends are fixed and enables M_A and M_C to be found from equations (9) and (10).

If the loading on each span is symmetrical but dissimilar then $\beta = \theta$ and $\psi = \theta$, and from equation (11),

$$M_B = \frac{2\,E\,I}{L + l}\,(\theta + \phi);\ M_A = \frac{3\,\theta\,E\,I}{L} - \tfrac{1}{2}\,M_B$$

$$M_C = \frac{3\,\phi\,E\,I}{l} - \tfrac{1}{2}\,M_B.$$

Note that these last three values are for fixed ends and symmetrical, but not necessarily similar, loading on equal or unequal spans.

The foregoing analysis covers all cases of continuous beams of two spans and moreover it enables all cases of beams of one span to be elucidated, thus :—For one span and two supports equations (3) and (4) will solve all cases of two fixed ends or one fixed and one freely supported. For example, if the end A, Fig. 6, is not fixed but freely supported, while B is fixed at an actual slope of zero, put M_A =zero in equation (4) and then

$$M_B = \frac{3\,E\,I\,\theta}{L}\ (\text{other end free}). \quad . (12)$$

When both ends are fixed and both actual slopes are zero, then from equations (3) and (4) we find

$$M_A = \frac{E\,I}{L}\,(4\,\beta - 2\,\theta) \quad . \quad . \quad . \quad . (13)$$

$$M_B = \frac{E\,I}{L}\,(4\,\theta - 2\,\beta)\ (\text{both ends fixed}) \quad (14)$$

The calculation of the free slopes (Fig. 1) will now be discussed. When the loading on one span is symmetrical, the procedure is simple and the free slope at each end of one span is half the area of the free bending moment diagram divided by E I. If there is more than one load on one span, the slopes due to each are algebraically additive even if the loading is not symmetrical. For a uniformly distributed load on one span, the area of half the free B.M. diagram is

$$\frac{w\,l^2}{8} \times \frac{2\,l}{3 \times 2} = \frac{w\,l^3}{24}$$

and so the slopes are

$$\frac{w\,l^3}{24\,E\,I}.$$

For a single central load W on one span, the half area is

$$\frac{W\,l}{4} \times \frac{l}{2} \times \frac{1}{2} = \frac{W\,l^2}{16}$$

and the slopes are

$$\frac{W\,l^2}{16\,E\,I}.$$

For a single non-central load W on one span distant a ft. from A and distant b ft. from B, when a is greater than b, it can be shown that the slope at A is

$$\frac{W}{6\,E\,I}\,\frac{a\,b\,(a + 2\,b)}{a + b}$$

and the slope at B is

$$\frac{W}{6\,E\,I}\,\frac{a\,b\,(2\,a + b)}{a + b}.$$

The maximum "free" deflection occurs at a distance $n\,a$ from A such that

$$n^2 = \frac{a + 2\,b}{3\,a}.$$

If there are two non-central symmetrical loads, each of W, then each slope $= \dfrac{W\,a\,b}{2\,E\,I}$.

For a distributed load varying from zero at support A to w at support B on a single span, the free slope at A is $\dfrac{7\,w\,L^3}{360\,E\,I}$ and the free slope at B is $\dfrac{8\,w\,L^3}{360\,E\,I}$. A bin post is an example.

When the loads on a span are numerous or irregular, standard graphical methods can be used for plotting the free B.M. diagram. The end slopes are obtainable thus :—From one support find the distance to the "centre of gravity" of the free B.M. diagram, as a fraction of the span; then the end slope at the other support is this fraction of the area of the free B.M. diagram divided by E I. Proceed similarly for the slope at the remaining end.

The reactions at the supports of continuous beams are easily found when the three pier moments are established. First find the free reactions with the

beam split at the intermediate support, as in Fig. 1. From the free reaction at A, subtract $\frac{M_B}{L}$ and the actual reaction at A is obtained. From the free reaction at C, subtract $\frac{M_B}{l}$ and the actual reaction at C is obtained. Note that M_B has different values, depending on whether the ends A and C are fixed or freely supported; see equations (8) and (11). Similarly for beams of one span, with the reservation that what is subtracted from one support must be added to the other.

Finally, a new method of calculating the deflection right along a continuous beam will be demonstrated, which is also applicable to a single span with one or both ends fixed horizontally. The method is simple, direct and much easier than the conventional procedure of double integration of the net B.M. diagram shown hatched in Fig. 2. The first step is to calculate or plot the deflection of two separate beams L and l, each considered as freely supported at the ends (Fig. 1). These deflections will cause concavity downwards in each span. The next step is to calculate the upward concavity of each of the four hypothetical cantilevers previously described, noting that there are only two cantilevers if the two ends of the continuous beam are not fixed horizontally. The third step is to subtract the upward concavity at any point from the downward concavity at the same point, the result being the required actual deflection of the continuous beam.

From any text-book, the deflection δ of a cantilever with a triangular bending moment diagram is

$$\delta = \frac{M}{E\,I}\left(\frac{x^2}{2} - \frac{x^3}{6\,L}\right) \quad . \quad (15)$$

where x is the distance from the abutment or fulcrum and M is the maximum bending moment. The maximum deflection Δ of a cantilever is $\frac{M\,L^2}{3\,E\,I}$. The upward concavity of each cantilever above the horizontal line A, B, C in Figs. 4 and 5, is obviously

$$\frac{x\,\Delta}{L} - \delta = \frac{M}{E\,I}\left(\frac{x^2}{2} - \frac{x^3}{6\,L} - \frac{L\,x}{3}\right) \quad . (16)$$

In the case of the two cantilevers M_B, x is measured from the intermediate support, to the left for the span L and to the right for the span l, using the appropriate value of M_B from equations (8) and (11) in place of M in equation (16). In the case of cantilevers M_A and M_C, x is measured from the end supports A and C, respectively, and the calculated values of M_A and M_C are used in place of M in equation (16). M_A and M_C do not exist if the ends A and C are not fixed.

The method is also applicable to a single span with one or both ends fixed, noting that if the end A is freely supported only one cantilever M_B has to be considered with its appropriate value from equation (12); with both ends fixed on one span, use equations (13) and (14).

When the two ends of a continuous beam of two spans are fixed, the upward concavities of the two cantilevers per span must be added and the total subtracted from the downward concavity which would be produced if the beam were split and the four ends freely supported. When the two ends of a beam of one span are fixed, the upward concavities of the two cantilevers must be added and the total subtracted from the free downward concavity.

Regarding the effect of sinking at the intermediate support, let the support sink e inches and the two ends be freely supported. Then the angle θ, Fig. 1, is reduced by the angle $\eta = \frac{e}{L}$ and the angle ϕ is reduced by the angle $\zeta = \frac{e}{l}$. The straightening required to give continuity at B, Fig. 2, is reduced by the angle $(\zeta + \eta)$ and the straightening pier moment M_B is reduced in the ratio of $(\phi + \theta)$ to $(\phi + \theta) - (\zeta + \eta)$. Therefore, the two fulcrum angles κ at B due to M_B are reduced, and from equation (8):—

$$M_B \text{ (free ends)} = 3\,E\,I\left(\frac{\phi + \theta}{L + l} - \frac{e}{L\,l}\right) \quad . \quad (17)$$

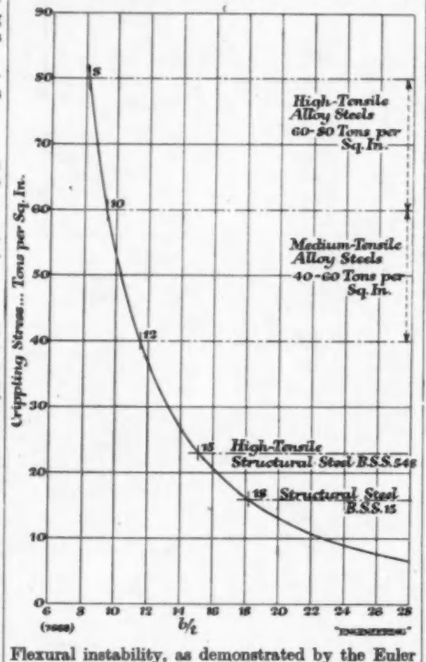
M_B is a cantilever moment producing upward concavity and its value is a maximum when $e = 0$. M_B is zero when $(\zeta + \eta) = (\theta + \phi)$ and we then have the condition that the bending moment at any point along the continuous beam is exactly the same as if the beam were split at B and the four ends freely supported.

If the support sinks still more, M_B becomes a moment producing downward concavity and reaches a maximum value equal to the free B.M. at B without an intermediate support. It is evident that sinking at the intermediate support increases the fixing moments M_A and M_C when such exist. To investigate the three pier moments M_A, M_B, M_C with a sunken intermediate support, subtract η from equation (3), add η to equation (4), add ζ to equation (5), and subtract ζ from equation (6). The reasoning of the kind used in the text following equation (6) enables the pier moments to be established easily.

HIGH-TENSILE STEEL IN DESIGN.

By Edgar W. Thomas, Ph.D., M.Sc., A.M.Inst.C.E., A.M.I.Struct.E.

The use of high-tensile steel alloys tends to a reduction in the thickness of structural members, and this reduction in thickness creates conditions favourable to the incidence of elastic instability.



Flexural instability, as demonstrated by the Euler theory in strut design, has long been recognised. It is shown in the following that this elastic instability may also be torsional in nature.

In the Euler theory of struts, and also in the derivation of strut formulæ based on initial curvature and accidental eccentricity, the strut is envisaged as a long thin rod free to deform laterally in any direction. Actually there is considerable difference between such a theoretical strut and the practical strut. Omitting the struts of curved cross section, the majority of strut section can be resolved into relatively thin rectangles, the crippling of any of which will cause failure. A simple example is an equal angle which may be treated as formed of two thin rectangles, an I-joist or channel of three rectangles, and so on.

Reverting to the thin rod referred to above, if this is replaced by a thin lath, the Euler formula can, of course, be readily deduced, and for the purpose of the present argument strain-energy methods will be used. Thus the strain-energy in flexure of the lath may be equated to the work done by the external load. At the critical condition when flexural instability occurs, this equation will enable the crippling stress to be derived, and results in Euler's formula.

The thin lath considered above was supported at the ends with both long edges free. In the practical strut, the thin component rectangles will have various edge conditions. Thus the outstanding legs or flanges of the angle, tee, channel or I sections may be considered as thin rectangles freely supported at the ends, with one long edge free and the other long edge partially restrained. The degree of this restraint is difficult to assess, but at the incidence of instability it will be small, and this long edge, for the purpose of the present analysis, will be taken as equivalent to "hinged." The deformation of such a thin strip under end load may be considered as flexure in a vertical plane and torsion in a horizontal plane. Thus at the incidence of elastic instability, the work done on the strut by the external end loading may now be equated to the strain energy in bending plus the strain energy in torsion. This results in the following expression for the crippling stress:

$$p = \frac{E \cdot \pi^2 \cdot t^2}{12 \cdot L^2} + N \cdot \frac{t^2}{b^2}$$

in which p = the crippling stress,
E = modulus of elasticity,
N = modulus of rigidity,
t = thickness of thin rectangle,
b = breadth of thin rectangle, and
L = length of thin rectangle.

It will be noticed that the expression for crippling stress is made up of two parts, one allowing for the flexural ratio of length to thickness, and one for the torsional ratio of breadth to thickness. The instability is of a torsional as well as of a flexural nature.

The results of applying this formula to steel alloys is shown in the accompanying diagram, an examination of which indicates that as the proof stress of the steel increases the tendency to instability also increases. Thus, in an 80 tons per square inch steel the ratio of breadth to thickness must not exceed 8 if instability is to be avoided; while for an ordinary structural mild steel the limiting ratio is 18. Recognition of this liability to instability is of great importance with the increasing use of high-strength alloy sheet and strip.

FOREMANSHIP TRAINING IN THE UNITED STATES.

By F. J. Burns Morton.

(*Continued from page* 325.)

Most medium-sized companies must make use both of conference inside the plant and of educational facilities outside. The real province of the formal training provided by the educational authorities lies in the instruction of younger men and trainees. Courses are offered by State universities, State Boards of Education, local schools, and private institutions, such as the Young Men's Christian Association. Training in supervision either forms part of the technical course or is arranged as a subsequent study after the completion of the technical instruction. This latter is naturally the more common. Sometimes it consists of a course of lectures, but more often the lecture-conference method is preferred. The subject-matter must be general, and must invoke principles common to all industries and be illustrated by material at hand. Attempts to make the course essentially practical are to be observed in the "case method" of instruction, where set practical problems are analysed and solved. The value of such courses, conducted by competent instructors, is not to be under-estimated, especially for younger men, who respond most quickly to intensive instruction.

Foremanship training is a problem in adult education, and as such requires special methods. The conference discussion has been found to produce the best results with older men; it is suitable to the subject matter, which is open to expressions of personal opinion, and it is admirably adapted to the type of persons being instructed. Thus the training of foremen in America is largely dependent on the effective organisation of discussion conferences.

To ensure the fullest advantages, conferences should conform to certain requirements, and the first and most important of these is the appointment of a competent chairman or leader. The person selected must be accepted by the group as capable, experienced, and as having the necessary authority. He should be able to plan ahead, not only the subject-matter for a series of conferences, but also the progress of each individual conference. He should avoid being regarded as a teacher, yet should be able to draw conclusions, emphasise principles, and indicate applications. He should have the ability to guide discussion, encourage debate, prevent diversions, avoid personal criticisms, inspire confidence, and should avoid being dogmatic and pedantic.

Secondly, conference groups should be as small as practicable. Ten members is regarded as a reasonable number for effective discussion. It is advisable not to exceed fifteen in a working group, if personal expressions of opinion are expected. Thirdly, the group should be composed of foremen of similar rank, experience and educational background, otherwise a danger exists of stifling discussion. Fourthly, conferences should be held regularly, weekly if possible, but not less frequently than fortnightly; although where the group contains highly qualified executives, monthly meetings might be preferred. Generally, the meetings are held in the company's time and on their premises, and these should be comfortable, ventilated, and free from noise and distraction. Meetings should last from an hour to an hour and a half, and should come to a definite close, not being allowed to drag on and dwindle out inconclusively.

Fifthly, controlled discussion should prevail, as distinct from teaching or instructing in the usual sense. The conduct of meetings, although a set piece of work is to be accomplished, should be informal, with free expression of opinion. In fact, all members should be encouraged to contribute to the discussions and to make suggestions, and should be prompted to be brief and to keep to the point. Sixthly, the topics for discussion should centre round immediate practical problems concerning the company, and should be kept as far as possible from the theoretical treatment of imaginary and general considerations. The subject-matter of the conference should be such as to enable the group to accomplish a definite piece of work either in recommending improvements or in acquiring information which may be immediately put into effect by each foreman. It is common for such groups to discuss new policies, programmes, and procedures, together with such problems as might arise in their application, and in this way to ensure uniformity of outlook.

Finally, conferences must be planned and properly prepared. Any information disseminated in written form ought to be brief and compelling. Unnecessary reading should be avoided, and statements should be simple and straightforward. It is advisable also to have the conclusions incorporated in a report and distributed among members, and here the omission of individual names is generally preferable.

The conference in America is not an unproductive committee with an unpredictable outcome, but a well-understood piece of machinery put to work to accomplish definite and tangible results. It is controlled, and discussion is directed. "Filibustering" and irrelevant diversions are not allowed. Free expression of opinion is permitted, provided that it is constructive. The procedure commences with adequate preparation, followed by an able presentation of the facts. Pertinent factors are discussed and additional experience is contributed. The information available, relevant to the problem under review, is summed up, and a conclusion is then drawn, either in the form of a plan of action for carrying out the decision, in making recommendations for improvements, or in establishing definite principles for common application. The real work of a conference is to realise composite opinion and uniform action; to correct, modify, or improve the outlook of members, so that they face the facts and see things in the company's best interests.

A wide variety of training plans exists, all of which have their merits and demerits and their suitability for certain circumstances, and these plans range from disconnected lectures to co-ordinated lectures; from lecture discussion to works conference; from correspondence courses to the supply of unconnected pamphlets; from the distribution of a planned study course to the foremen's club.

It might be concluded that the most suitable method of training will naturally depend on a number of factors: such as the size of the firm, and the character of its organisation, whether widespread or concentrated; the nature of the supervisory job; the degree to which technical knowledge and trade experience are essential; the educational standard, general capacity, and degree of experience in existing foremen; the extent to which previous training has already taken place; the personal atmosphere prevailing and the co-operation between management and supervisors; the relations with labour; the relative urgency and nature of the problems that the training is expected to solve; the nature and extent of any impending changes or extensions; whether training is to improve existing foremen or provide prospective supervisors; the local facilities available for formal training; and the availability of expert training staff within the company or without, either as consultants or education authorities.

A good deal of work has been done in investigating the principles of teaching employed, and in selecting the most suitable medium. The consensus of American experience in this respect might be summarised as follows: all training should commence with a careful study of the aims to be achieved as this will determine the most desirable procedure to adopt; for instance, the improvement of technical ability would be tackled differently from the task of effecting a change in industrial relations policy, and factory requirements differ from sales activities. There is an insistence on intensive training as distinct from general and extended instruction, and there is a distinct urge to develop maximum skill in the minimum of time.

It is considered essential to begin by giving a bird's-eye view of what the training sets out to do, and what field it intends to cover, so that each detailed step is seen in relation to the whole. The correct method must be insisted on from the start; the method of treatment must be practical; principles must be converted into day-to-day practice, with plenty of current examples; and actual operations must be used as the basic material, concrete problems from actual experience being preferable. Accuracy must be insisted on as a preliminary to speed, and time should be taken, especially in the beginning, to ensure complete understanding of one step before going on to the next.

Each step in training should deal with a specific subject, complete in itself, and progress should follow a logical sequence, so that one subject is related to the next. This calls for a carefully planned programme. Training is best regarded as a continuous process, in which day-to-day contacts can be used to supplement group meetings. Finally, the medium of training employed should stress the need for initiative, the ability to apply principles, ingenuity in making the most of past experience in solving current problems, and the desire for continuous improvement.

The method and means of training will naturally vary with the number of foremen, their ability, and their educational background. Specialists in training have brought great variety of methods and a wide choice of material to their aid; for instance, photography has been used with outstanding success, especially in connection with time and motion study. Films demonstrating methods of work before and after rearrangement, the principles affecting layout of work-bench, the ease of operation, the effect of lighting and seating, the advantage of conveniently placed materials, and so forth, all help the foreman to view his job from a different angle. Sound films have been employed to demonstrate the right from the wrong method of selling to customers. Some firms have varied their training by arranging visits either to special jobs in one of their own departments, to one of their other works, or to some other factory in the same or a similar industry. Comparable methods can be used, of course, with the formal night-school instruction.

A common feature to be observed is the distribution of booklets or pamphlets to foremen as a supplement to, and in preparation for, discussion conferences. These are of two kinds, either a complete set of instruction booklets or miscellaneous pamphlets on current problems. In this connection, it may be of interest to describe the publications of a typical institution: the National Foremen's Institute. This institute, started in 1929 and consisting of specialists in training, industrial relations, etc., has produced a set of 24 manuals covering the entire field of foremanship. The course is supplemented by a conference leader's manual, setting out the general principles to follow and the detailed conduct of each meeting. This greatly reduces the work of planning and preparing materials for meetings, and makes the best use of the information presented. Foremen are each supplied with a copy of the manual to read in preparation for the next conference. The manuals are specially designed to be brief and yet comprehensive, and are clear and easily readable. In addition, pamphlets are issued from time to time on miscellaneous subjects of current importance, such as the Wagner Labour Relations Act, and the Wages and Hours Act. Separate brochures are also available to draw attention to new methods, cost reduction, and similar subjects. Perhaps the most comparable publications in this country are the shilling booklets for salesmen issued by Herbert Casson, and it is a fact that many of the largest companies in America have taken advantage of this service. Other institutions, the best known of which is the National Metal Trades Association, publish training manuals along similar lines.

Firms not wishing to make use of these more expensive publications often resort to a selected manual, a copy of which is given to every foreman, some particular chapter being used as a text for the discussion conference, and being supplementary to it. Training at the American Cyanamid Company, New Jersey, for example, is based on Tead's *Human Nature and Management*, and Lincoln and Prosser's *The Employer, The Employee, and The Job*. The University of Michigan has recently drawn up a recommended "foremen's bookshelf." This short list of selected volumes includes Schell's *Manual for Executives and Foremen*; Reitell's *How to be a Good Foreman*; Gardiner's *Better Foremanship*; and Smith's *Psychology for Executives*. In addition, two periodicals are available for foremen, namely, *Management Information*, edited by Glen Gardiner and issued weekly through the Elliott Service; and *Supervision*, published monthly. There is no doubt that the provision of suitable text-books and current periodicals, an ample supply of which is readily available in America, is a valuable stimulant in the preparation, up-grading and training of foremen, and provides means whereby men can improve themselves.

As regards the training of conference leaders, the best methods for conducting meetings, the most suitable material to use, and the experience of other firms, an immense literature is available. The Federal Board of Vocational Education in Washington have issued a number of condensed and highly informative pamphlets, the information in which is most readily available in *Foremanship and Supervision*, a text-book written by Frank Cushman, a consultant in vocational education employed by the Federal Board.

It should not be concluded from the foregoing that foremanship training in American industrial concerns always adheres to the use of published manuals, books, or pamphlets. Most companies plan their own programmes and make their own arrangements according to their immediate circumstances and requirements. Full details of the training procedures adopted by many of the best-known companies in America have been made available by the Policyholders Service Bureau of the Metropolitan Life Insurance Company, New York in two booklets, *Foremen Training Plans* and *Training Supervisors and Keymen*. The Department of Manufacture of the Chamber of Commerce of the United States, Washington, D.C., have also issued

an informative booklet, *Typical Foremanship Programmes and Topics*, which is a compilation of practices, mainly from companies conducting their own courses. A useful brochure has also been issued by the same department on *Foremanship*, containing a condensed statement of the experience of 126 industries. This forms a valuable summary of opinion.

A review of supervisory training experience was made by Allen B. Gates, of the Eastman Kodak Company, at the Seventh International Management Congress at Washington in 1938, wherein he summarised the programme content common to most American concerns as comprising (1) the principles of organisation and management; (2) personnel problems; (3) cost control (effective use of equipment, materials and labour); (4) quality control (adherence to established standards); and (5) control of production (control of quantity and time accomplishment). It should be noted, in comparison with British foremanship, that the general tendency in America is to emphasise the aspect of supervision and its bearing on production, and to relieve the foreman as far as possible of all responsibility for the technical and trade problems with which the British foreman is so largely concerned, so that programmes of training would have to be modified to this extent.

In the following brief description of the essential points to be observed in some training plans operating in America, the intention is to show the wide variety and the recent trends, rather than to give an account of typical schemes common to the large majority of concerns. Each firm, faced with its own internal domestic problems, seeks the best solution to them from a choice of the many different arrangements, methods, and media available. Some firms, in their training arrangements, tend to dismiss the formal training aspect and to place the main emphasis on the solving of actual problems of operation. C. P. McCormick and Company, of Baltimore, Maryland, have created Junior Boards of Directors, one for Sales and one for Production. The most qualified departmental executives are chosen to serve on this committee, which meets weekly, and is advisory in character. Ways and means of improving processes and operations are the chief function of the Junior Board, whose members are changed from time to time at the discretion of the managing director. It is claimed that this arrangement accomplishes a great deal in the way of encouraging improvements, stimulating suggestions, training executives, facilitating promotional possibilities, and creating co-operation between colleagues.

Another arrangement of an executive character is provided in a description by the University of Michigan of a firm employing 5,000 men and 200 foremen, in which a deterioration of industrial relations was to be stemmed by the influence of the foremen. In this plant, regular foremen's conferences were held by the works manager on problems arising from the day-to-day operation of the business. The need for a better understanding between foremen and workmen was achieved in this case by the periodic value-rating of workmen, on which wage rates were dependent. This work of man and job rating, which is finding wider application in America, was the piece of work set for the foremen to accomplish. It is acknowledged that, where the foremen's training conference can be set a piece of work, or given advisory or executive powers on problems of immediate urgency, a greater interest is taken by the foremen and the immediate benefit is more easily seen and measured.

(*To be continued.*)

The Institution of Engineers and Shipbuilders in Scotland.—The Council of the Institution of Engineers and Shipbuilders in Scotland has made several awards in respect of papers read during the 1940-41 session. The Gold Medal has been awarded to Dr. G. G. McDonald, B.Sc., for his paper "Dimensional Analysis of Centrifugal Pump and Blower Performance," and Institution Premiums to Messrs. J. L. Kent and R. S. Cutland, for their paper "Experiments in Rough Water with a Single-Screw Ship Model," and to Mr. Donald V. H. Smith, for his paper "District Heating and its Relation to Housing and Town Planning."

GENERAL OBSERVATIONS ON VIBRATION.*

By J. Calderwood, M.Sc.

(*Concluded from page* 340.)

To turn from the hull to the framing of a reciprocating engine: this, if insufficiently stiff, may vibrate transversely or be subject to a twisting vibration. The latter is not torsional, but is a transverse vibration in which the opposite ends of the engine are out of phase. Generally, with sound seatings and stiff framing to the engine, such vibration should not occur, although as engine speeds are increasing it may be found even with a stiff design of engine framing. To avoid this, it has been necessary, in some cases, to adopt cast-steel for the framing solely on account of its greater modulus of elasticity, which increases the stiffness of the frame. The author has also had reported to him, although he has not had personal experience of either case, two occasions where a longitudinal (fore-and-aft) vibration occurred on a three-cylinder triple-expansion engine. In both cases the vibration had a frequency four times the engine revolution speed and was of very considerable amplitude. In one case the fitting of balance weights on the crankshaft considerably reduced the trouble, although why they should have done so is not at all evident. In the other case, the author did not hear of any cure being effected. These instances are mentioned because of their unusual nature.

A form of vibration which arises occasionally is that caused by the air inlet on internal-combustion engines. This may have two effects, one purely an unpleasant sensation on the ear drums in certain parts of the machinery space; the other a definite vibration of part of the ship's structure. The author has observed three cases in particular; the first two of the former kind, the third of the latter. In the first of these cases, the frequency of pulsations of the engine suction corresponded approximately to the "organ-pipe" frequency between the suction intake and the end of the tunnel. There was no noticeable unpleasant effect from the pulsating suction in the engine-room, but at the aft end of the tunnel at certain engine speeds the pulsating effect on the ear drums was almost unbearable. No attempt was made to cure this. In the other case, the double length of the engine-room corresponded to an "organ-pipe" frequency similar to that of the air pulsation, and here again the effect on the ear drums was very unpleasant; the effect was felt at most parts of the engine-room. The pulsations here were damped out by means of a Venturi intake, which prevented air pulsations passing back from the suction chamber into the engine-room. A similar condition on some stationary engines, some years ago, caused broken windows at a distance of several hundred yards. This also was cured by the Venturi inlets. It was the experience with this stationary engine that led to the arrangement being adopted on the marine installation mentioned above.

The instance of structural vibration due to air pulsation which the author observed occurred in a ship where it was exceptionally important to ensure, as far as possible, freedom from vibration. Generally, this ship was exceptionally free from vibration, but there was one small public room above the engine-room, the floor of which suffered from very severe vibration, the natural frequency of this floor corresponding with the frequency of pulsation of the engine suction. It will be understood that the air waves which have been referred to above are waves having frequencies below the audible range.

Another unusual type of vibration observed is that due to an organ-pipe effect of the steam flow between boilers and turbines. In this particular installation, in addition to the normal vibration having frequencies varying with the engine speed, there were evident at all speeds small torsional vibrations, and also a general vibration of the whole of the turbines and gear casings having a frequency which remained practically constant at whatever speed the machinery was running. Fortunately, the vibration was not of serious magnitude; it was found that its frequency corresponded to the organ-pipe frequency of the length of the steam piping between the boiler and the stop valve. Such a vibration is, of course, of the same type as the well-known water-hammer in pipes. The author only knows of this one minor instance but it is quite possible that serious vibration might arise in this manner.

A somewhat similar effect has been noticed on stationary pumping plant; in this case, however, the excitation of vibration was due to impulses from the engine. The pumps, driven by a reciprocating engine, were delivering from an open-ended pipe about 250 ft. long. At the full speed, there was vibration having a frequency which corresponded to one of the components of cyclic irregularity of the engine. The irregularity was transmitted through the driving gear to the pump bucket, and the driving system between the crankshaft and the pump buckets had a frequency corresponding to this torsional vibration, setting up bucket vibration which, in turn, excited a wave effect in the open-ended delivery pipe. This was possibly magnified by the fact that this frequency corresponded approximately to one-half the organ-pipe frequency of the delivery pipe. The case is of particular interest because of the extremely high stresses that were set up, the delivery pipes fracturing after a comparatively short period in service. The actual maximum static pressure in the pipes was of the order of 100 lb. per square inch, while, to cause the fractures which occurred the vibration must have been setting up pressures of the order of 1,000 lb. to 1,500 lb. per square inch.

There are, of course, many secondary types of vibration which can arise in any marine installation, such as the transverse vibration of pipes, the vibration of small auxiliaries on their seatings, and local vibration of various parts of the ship's hull excited by forces transmitted from the engine. It is usually a comparatively simple matter to eliminate them, either by an increase or a reduction in the stiffness of the part affected.

Torsional vibration of engine shafting is a subject which has been thoroughly treated in various papers and books. There are, however, three questions which might be dealt with. The first is that of forces acting at a node; the second, the type of vibration that arises due to gear errors; and the third, the vibration which may occur with more than one node in the intermediate shafting. The usually accepted method of summating the effect of the torsional combinations from the various cylinders of a multi-cylinder engine is similar to the method of the normal balancing of couples. It is based on the assumption that a periodic force at a node will not cause vibration, and that the ability of force to cause vibration is directly proportional to its distance from the node. As already explained, the first assumption is incorrect, and, therefore, academically at least, the whole of this method is incorrect. It is, however, sufficiently accurate for most practical purposes, provided that the torsional vibration is of such magnitude that it is only of importance when the forces closely synchronise with the natural frequency, and is the only reasonably simple method of dealing with the torsional vibration from a multi-cylinder engine.

It is, however, not impossible for the torsional stresses due to periodic forces to be considerable, even at forced frequencies appreciably different from the natural frequency. The only method of dealing with it, therefore, is to calculate the actual vibration from the forces at each cylinder and summate them. Such a condition is not likely to arise in a marine propelling installation.

The question of vibration arising due to errors in gear cutting is one that has been neglected in most papers and books on the subject. The treatment is quite different from that of vibration due to forces. In the first place, if the gears are at an anti-node of free vibration of the system, *i.e.*, the position where a force would cause the maximum of stress, the vibration due to the gear error is completely negligible even though the error may be considerable. On the other hand, if the gears are at the node of free vibration, stresses that arise are extremely heavy, even with the smallest of periodic errors. Fortunately, the gears do not have to be far removed from the node in order greatly to reduce the effect of any gear errors in producing vibration. In principle, the points to be watched as regards gear errors are (1) if possible, avoid having gears at or near the position of a node of free vibration; and (2) if other considerations make it advantageous to have the gears at a node, then ensure that there is no gear error of a frequency that can coincide with any of the free natural frequencies of the system within the running range of speeds.

In general, in dealing with marine installations, the shaft between the propeller and the engine is treated as being a light shaft. So long as the forced frequencies are low, this is permissible, but when the shafting is of considerable length, there will be natural frequencies of free vibration with two nodes within the shaft, having a frequency of the order of 30 cycles to 60 cycles per second. If the propelling machinery is of a type in which forces of this order of frequency arise, the shaft should be treated as a heavy shaft and the calculation made accordingly. It must be remembered that, in this particular type of vibration, almost the only damping that occurs is the internal damping in the shaft itself, so that comparatively small forces may set up very heavy vibration.

One effect of torsional vibration that is often overlooked is its influence on propeller efficiency. Even with comparatively moderate amplitude, the rotational speed of the propeller may vary during the revolution by ±40 to 50 per cent., and with severe vibration the variation may be well in excess of ± 100 per cent. It is evident that such variation in the propeller rotational speed is the equivalent, as regards efficiency, of an

* Paper read at a meeting of the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-on-Tyne, on March 14, 1941. Abridged.

extremely bad distribution of wake and that, even with very moderate amplitudes, there will be considerable loss of propeller efficiency. The problem involved is somewhat complex and is rather one for a specialist in propeller design than for the engine builder; but it would be interesting to know whether this question has been given consideration by propeller designers, and whether they can state limits of variation of rotational speed beyond which the loss of efficiency becomes serious.

The elimination of vibration should be treated, in general, by ensuring in the design stage that there is no synchronism between periodic forces and natural frequencies of the engine or ship. Sometimes, however, conditions arise which make it impossible to keep clear of certain cases of synchronism which will cause vibration. For the cure of the vibration in such circumstances a very large number of different devices have been developed. These fall into two general classes: (1) true dampers, in which some type of frictional damping element is introduced to reduce the maximum point on the dynamic-magnifier curve; and (2) detuners (these are sometimes also described as dampers or as dynamic dampers) which introduce an additional element into the system that alters the natural frequency or in some way ensures that the vibration is absorbed by a unit designed to take it up, while leaving the main part of the system free from vibration.

The true dampers essentially involve the absorption of power, and in efficiently damping any serious vibration, when running on or very close to the critical speed, the power absorption is very considerable. In a marine propelling engine with a comparatively long shaft, the propeller itself acts as a damper of this type and the author has had the opportunity of measuring, in two cases, the amount of power absorbed when running at the critical speed. In both instances, the critical speed was far removed from the normal running speed and so was not of serious importance. In one, an engine of 1,500 h.p. at 125 r.p.m., had its major single-node torsional critical at 55 r.p.m. A curve was drawn of the brake horse-power when running through this critical speed and it was found that at about 35 r.p.m. it started to rise noticeably above the normal curve. At the critical speed the power calculated by propeller law from readings at higher and lower speeds should have been 89 brake horse-power. The actual power recorded was 276, showing 187 brake horse-power absorbed by damping. Towards 75 r.p.m. to 80 r.p.m. the power fell again to the normal.

In the other case the proportional increase in power was similar, although it occurred nearer to the normal running speed and the actual power absorption was higher. This should indicate that true dampers should never be used for eliminating vibration at normal running speeds, as the power wastage is very serious. True dampers, therefore, should only be used where there is a critical speed that must be passed through, and which might cause serious consequences even during the few seconds the engine is running near the critical when running up to its normal speed.

For torsional vibrating systems, asynchronous couplings have been commonly used with considerable success. These couplings, of which the Bibby was probably the first example in common use, provide an elasticity varying with the amplitude so that, as soon as the amplitude starts to build up, the natural frequency of the system alters. This type of coupling can only be usefully employed in a comparatively rigid system, as there are practical limitations to the flexibility that can be introduced into the coupling, and this flexibility must form a reasonably high proportion of the total flexibility of the system. Such couplings could be of no value for eliminating single-node vibration of a marine propelling unit, but might be very useful for two-node vibrations of a marine propelling unit involving gears. The only method that has been used for eliminating hull vibrations is the flexible mounting of the engine. This, in effect, alters the natural frequency of the combined unit of hull and engine, bringing it so low that the vibration on the hull is practically nil. The practical difficulties are, however, very great and, so far as is known, it has only been applied in comparatively small engines.

A promising method of eliminating vibration due to engine pulsations on twin-screw ships is the fitting of synchronous alternators on the two engines, so that they are kept in a definite phase relation one to the other, this relation being chosen at the point where the minimum vibration arises. This arrangement has been tried out with success in one or two ships, but it is rather expensive and has not been developed to any great extent. It is, however, one of the rather important advantages claimed for alternating-current electric drive that, all of the engines being fitted with alternators, they can easily be synchronised at the angles that ensure freedom from vibration.

One principle of vibration elimination has been adopted in a few instances for a transverse vibration, and in recent years has been fairly commonly adopted for torsional vibration. If, at the position of the vibrating force, a mass is elastically connected to the system, the connection being such that the natural frequency of the mass about the point of the vibrating force, assuming the latter to be attached to an infinite mass, is equal to the frequency of the vibrating force, then this connected mass will completely balance the vibrating force, so that the rest of the structure is entirely free from vibration. This arrangement has been used with plain elastic coupling of the mass both for transverse and torsional vibrations. It has the disadvantage that it can be designed for one speed of rotation only, unless a considerable number of different masses are attached each at its own separate elastic mounting, which in most cases is quite impracticable. For torsional vibration there has been developed from this idea the pendulum detuner, in which the elastic connection is supplied by centrifugal force. In principle, the pendulum detuner consists of heavy masses connected by short pendulums to suitable points on the outside of a disc. The frequency of vibration of the pendulum will alter with the centrifugal force and maintains constant relation to the revolution speed, so that the unit can be designed to have a frequency of, say, six times or any other required multiple of the revolution speed. In theory, one of these detuners should be mounted at each cylinder in order to absorb the pulsating force from that cylinder. In practice, it has been found generally that the detuner mounted anywhere on the engine will sufficiently absorb the vibration to eliminate serious stresses. This type of detuner can only be designed for one order of vibration, but if necessary more than one can be fitted to the engine. Generally, however, not more than one of the orders of forced vibration is serious.

While this arrangement almost completely eliminates the order of vibration for which it is designed, it modifies and may increase in amplitude vibrations of other orders, and care must be taken to ensure that the vibration of these other orders is not increased to a serious extent.

A device similar to the pendulum detuner but adapted for transverse vibration, would be a very useful accessory in many cases, but no means of overcoming the difficulty of altering the frequency of the detuner according to the speed of the engine has yet been proposed, and it seems difficult to envisage any satisfactory way of doing this.

For the measurement of vibration there are a considerable number of instruments now on the market. While many of these are very fine instruments, they suffer from a common defect that they are completely non-selective and give the same magnification to a vibration whatever its frequency. As a result, if a system has a comparatively large amplitude at a very low frequency, combined with small amplitude of high frequency, the latter is very difficult to pick out from the records, although it may be much the more serious of the two types of vibration being measured. The method of driving vibration instruments may cause false readings, particularly in the case of torsional vibrations, where a belt is often used. This may give the most serious error. The author has had experience of an instrument recording an amplitude some 30 to 40 times as great as the actual amplitude being measured, due to the frequency of the belt synchronising with the frequency being measured. It is essential with any type of vibration meter that the connection to the vibrating body should have the maximum possible rigidity. With anything less than infinite rigidity, the vibration recorded will be greater than the vibration being measured, unless extremely flexible connections are used giving a natural frequency of connection lower than $\sqrt{2}$ times the frequency being measured.

THE ROLLING OF A MAGNESIUM ALLOY.*

By PROFESSOR W. R. D. JONES, D.Sc., and L. POWELL, B.Sc.

THIS is a report of an investigation carried out on lines similar to those recorded in "The Rolling of Magnesium,"† and deals with experiments that have been made to study the effect of cold work and subsequent annealing on an alloy of magnesium chosen on account of its proved general usefulness. Briefly, the work to be described consisted of the production of No. 10-gauge sheets which were then cold rolled with varying degrees of deformation to No. 16 gauge. The sheets were subsequently annealed at different temperatures and tested. The experiments were carried out in two stages: (1) on sheets rolled direct from cast slabs, and (2) on sheets rolled from slabs extruded from a chill-cast circular ingot that had been teemed from the same ladle of molten alloy. In this way a comparison could be made between the properties of sheets rolled from cast slabs and those rolled from an extruded slab of the same composition. If the initial extrusion operation now generally carried out on the ingot could be eliminated, the production of magnesium alloy sheets might be cheapened.

SHEETS ROLLED FROM CAST SLABS.

Slabs of the magnesium alloy Elektron AM503 were cast by Messrs. Magnesium Elektron, Limited, at their works in Manchester, using the mould described in the previous report.* The analysis of the material in the ladle from which the slabs were cast was: manganese 2·28, aluminium 0·05, silicon 0·02, copper 0·01 per cent., and zinc a trace. The surfaces of the ingot slabs were sufficiently good not to require machining before the slabs were rolled.

Hot Rolling of the Slabs.—The rolling operations were carried out on a Robertson three-high, 24-in., non-reversing mill, using a rolling speed of 60 ft. per minute. The rolls, in a highly polished condition, were preheated to about 90 deg. C. for hot rolling. The slabs were heated at 450 deg. C. for 2 hours and then hot rolled in the "straight" direction, *i.e.*, that in which the metal had been teemed. After each pass the slab was turned upside down.

The original thickness of the slab was $\frac{13}{16}$ in. and the successive thicknesses, in 64ths of an inch, during the course of the rolling operations, were: 44, 42, 40, 37, 36, 32, 30, 28, 25, 22, and 21. It was necessary in a few cases to straighten the slabs after the ninth or tenth operation and this was done by passing the slab diagonally through the rolls without increasing the draft. After the eleventh operation the slabs were too long for the reheating furnace and were cooled and cut into halves. The sheets were then reheated at 450 deg. C. for 1 hour, and further rolled, the successive thicknesses being Nos. 2, 4, 5, 7, and 9-10 S.W.G. The final hot-rolled No. 10-gauge sheets were annealed for 1½ hours at 450 deg. C. and cooled slowly in the furnace. It was not necessary to pickle the sheets after heat-treatment.

Hot and Cold Rolling of the Sheets to No. 16 Gauge.—The No. 10 gauge sheets (0·128 in. thick) were rolled down to No. 16 gauge sheets (0·064 in. thick) by hot rolling, by cold rolling, or by a combination of these carried out in such a manner that the finished sheets, all at No. 16 gauge, had received the following percentage amounts of cold extension: 0, 5, 10, 25, 50, 75, and 100. In any combination of hot rolling, followed by cold rolling, the sheets were annealed at 450 deg. C. for 1½ hours after the hot rolling and before the subsequent cold rolling. During the cold rolling stage, the sheets—with the exception noted below—were not given any intermediate annealing. Cold rolling was carried out with highly polished cold rolls and was conducted very slowly. Sheets that were cold rolled from No. 10 to No. 16 gauge, *i.e.*, suffered 100 per cent. cold extension, were very poor and showed excessive edge cracking even with the small drafts used. In this case it was necessary to use intermediate annealing at 450 deg. C. for half an hour until the thickness had been reduced to about 0·09 in., *i.e.*, No. 13 gauge. After the sheet had been reduced to No. 13 gauge the cold rolling to No. 16 gauge was performed without intermediate annealing. Intermediate annealing was not necessary for sheets that were given 75 per cent., or less, cold work, because the thickness of the sheets after the hot rolling and before the cold rolling was No. 13 gauge or less. Batches of sheets, each of which contained one sheet with each of these amounts of cold extension, were made up. One of these batches was tested in the unannealed condition, while the others were annealed for 1 hour at temperatures of 100 deg., 200 deg., 300 deg., 400 deg., and 500 deg. C., respectively.

Mechanical Tests.—The tensile tests were carried out on an Olsen hand-operated 10,000 lb. machine, using spherical-seated self-centring grips. B.S.I. test-pieces were prepared from blanks sawn from the sheets at positions transverse, parallel, and inclined at 45 deg. to the direction of rolling. The limit of proportionality and the proof stress were determined graphically from load-extension diagrams obtained by means of a Gerard extensometer. The proof stress has been taken as that stress giving a permanent extension of not more than 0·1 per cent. of the gauge length of 2 in. The hardness of the sheets was determined by using a diamond indenter with a load of 5 kg. sustained for 30 seconds.

Discussion of the Results on Sheets Produced from Cast Slabs.—In the "strong" direction, *i.e.*, transverse to the direction of rolling, the effect of cold work on the limit of proportionality was practically negligible, but if the sheets were annealed subsequently there was a slight general increase in the values with the annealing temperature up to 300 deg. C., above which annealing was harmful. Annealing had little effect on sheets that had been subjected to 50 per cent. cold extension

* Paper presented to the Institute of Metals for written discussion. Abridged.

† See *Jl. Inst. Met.*, vol. 66, page 331 (1940).

* *Loc. cit.*

—the values falling from 4 tons per square inch for the hot-rolled sheet to about 2½ tons per square inch—a value which was not improved by annealing even at 500 deg. C. With a greater amount of cold deformation annealing at 100 deg. C. improved the values, but if the annealing temperature was higher than 300 deg. C. the figures were decreased. It seems that there was no advantage in annealing at temperatures higher than 300 deg. C.—in fact the greater the amount of cold work the lower was the annealing temperature required to give the greatest improvement. Annealing at 500 deg. C. decreased the results to a constant value, which was independent of the amount of cold work.

Figures for the two "weaker" directions, *i.e.*, parallel and diagonal to the direction of rolling, were much lower, but these do not appear to be as different as was found to be the case with unalloyed sheets. Annealing at temperatures higher than 300 deg. C. was harmful—the figures for more than 50 per cent. cold extension were very low. Directionality was still pronounced, but was lessened after annealing at 300 deg. C. Annealing above this temperature reduced the test values and also decreased the directionality, probably because the values in the strong direction were decreased relatively much more than those in the weaker directions. The test results of specimens made at 45 deg. to the direction of rolling were generally between those for the transverse and parallel directions, being as a rule much nearer the latter, *i.e.*, it is definitely a "weak" direction.

The proof stress was decreased somewhat by an increase in the amount of cold work—a decrease that was accentuated by annealing. Annealing above 300 deg. C. was not necessary and brought the values to more or less constant figures, which were lower than those given after annealing at 300 deg. C. This applied to each of the three directions and the values, although not varying greatly with increasing amounts of cold work after annealing at 400 deg. to 500 deg. C., were lower than the test results of sheets that had not been annealed.

Cold work up to about 50 per cent. extension had little effect on the ultimate stress, but with a greater degree of cold work the values decreased seriously, particularly in the "weak" directions—those for 100 per cent. cold extension had decreased to the low value of 12½ tons per square inch. There was no advantage in an annealing temperature higher than 300 deg. C. There was some evidence that very small amounts of cold work were inclined to be harmful, especially if the sheets were subsequently annealed. Specimens made from the sheet in a direction parallel with that of rolling showed that the difference in strength when compared with those cut from the transverse (or "strong") direction depended on the amount of cold work. If the amount of cold work exceeded 50 per cent. extension the strength decreased considerably. Annealing improved the results somewhat—an improvement that was most noticeable when the amount of cold work was greatest.

Cold work decreased the reduction of area in all directions of testing. Small amounts of cold work equivalent to about 5 per cent. extension were decidedly harmful. The low values were improved by annealing, but in any set of results the discontinuity at 5 per cent. persisted on annealing. For medium amounts of cold work annealing up to 300 deg. C. increased the values which were, however, not as high as those given by the hot-rolled sheets. With heavy amounts of cold work the reduction of area became negligible for the weaker directions, but ductility was improved by annealing to a more or less constant value of 9 per cent. to 10 per cent. in the strong direction. The elongation figures were decreased considerably by cold work, and if the amounts were less than 10 per cent. extension annealing was of no value in improving the figures. However, with 25 per cent. to 50 per cent. cold rolling, annealing at 300 deg. C. restored the elongation to values that were almost as good as those for hot-rolled sheets. Heavier cold rolling should be followed by annealing at 400 deg. C. for the greatest improvement.

The results of the hardness determinations showed that the hardness increased with cold work up to 25 per cent. extension, after which the figures remained fairly constant at between 48 and 50 D.P. hardness. In the case of the hot-rolled sheets annealing at low temperatures produced a noticeable increase in hardness. In the case of the cold-rolled sheets there was a constant rate of decrease of hardness at each annealing temperature up to 500 deg. C.—a rate which was independent of the amount of cold work. The hardness depended, therefore, on the temperature of annealing and was a constant for any particular annealing temperature irrespective of the amount of cold work given to the sheet—the higher the annealing temperature the lower was the hardness.

Summarising these results, it can be stated that while the tenacity figures were not seriously affected by cold work, the ductility figures were decreased considerably. Annealing on the whole was permissible if the temperature was not higher than 300 deg. C. The hardness of the sheets became a constant value related to the annealing temperature and not to the amount of cold work. Another interesting feature was that, provided the amount of cold work was not greater than that equivalent to about 50 per cent. extension, little harm was done by annealing. The examination of specimens under the microscope showed that the material was clean and free from inclusions. Etching with an alcoholic solution containing 4 per cent. nitric acid revealed the grain boundaries readily and showed that the alloy was a solid solution. The grain-size was very much smaller than that of magnesium metal which had received exactly similar treatment.

(To be continued.)

COLOURED CHIPPINGS FOR ROAD SURFACES.

Present conditions have naturally affected normal road building and road maintenance methods. For example, some types of roads, such as aerodrome runways, may be needed for special or temporary purposes. The surface dressing may be required to match the colour of existing surfaces or differentiation may be necessary, and it is important from the point of view of both rapidity of construction and economy of transport to know where differently-coloured chippings are obtainable. This information is provided in a leaflet, *Wartime Road Note No.* 2, just issued by the Road Research Laboratory of the Department of Scientific and Industrial Research, in co-operation with the Ministry of War Transport, and entitled "Sources of Naturally-Coloured Chippings in Great Britain." The leaflet deals mainly with black or dark grey stones, the latter being abundant in this country; with the darker shades of red and brown, which are not uncommon; and with green stones, these being relatively scarce, most of the green rocks available being either too dark or too grey. Conditions affecting colour of the chippings, such as the state of subdivision and dryness and weakness of the stone, are discussed. Practically all rocks, even if dense black in the lump, give a grey dust, and dry rocks are lighter in tone than wet rocks.

The sources of chippings of the three main colour classifications mentioned above are given in separate tables, the name and situation of the quarry concerned, the number of men employed (which forms a rough guide as to output), the petrological name of the rock, the trade group to which it belongs, characteristic colour, etc., being stated. A warning is given that highly-coloured rocks may be structurally weak since the colouring is often associated with weathering, but, apart from this, the question of strength is not considered. When laid as surface dressings, small scale tests on concrete have shown that the colours of a number of stones appear much stronger than in hand samples. A section of the leaflet deals with some substitute materials, such as sandstones and limestones impregnated with hematite and available as waste from iron mines; shale residues from dumps that have been on fire; and slag from iron-smelting or glass works. A cautionary note is appended regarding this latter material, as it may break down into sharp-edged fragments liable to cause excessive tyre wear. The leaflet may be obtained from H.M. Stationery Office, Kingsway, London, W.C.2, price 6*d.* net.

PRESSED-STEEL BUILDING CONSTRUCTION.

MESSRS. THE LETOURNEAU CORPORATION, PEORIA, ILLINOIS, U.S.A.

Fig. 1. Dwelling House Constructed of Pressed-Steel Blocks.

ALL-WELDED PRESS FOR STEEL BUILDING BLOCKS.

Most of the types of steel houses that have been designed in the past have been constructed on a framework of more or less conventional form. The building illustrated in Fig. 1, above, which has been erected by Messrs. The LeTourneau Corporation, Peoria, Illinois, U.S.A., differs from the usual type, however, in that it is constructed throughout of prefabricated arc-welded steel blocks which form the framework and wall unit in one member. Each block consists of two panels, with finished dimensions of 7 ft. 8 in. in length and 3 ft. 10 in. in width, pressed from 12-gauge steel sheets. The panels are welded together, with interior spacers set at intervals of not more than 24 in. The finished box sections are 6 in. thick for walls and 18 in. thick for roofs, and are welded together, thus forming a rigid and fireproof construction. Electric wiring, water and other pipes, etc., are led through the box sections, which can then be filled with insulating compound. The building illustrated is a dwelling house. It covers a site 43 ft. 8 in. wide and 70 ft. deep, and contains three reception rooms and four bedrooms, and its construction occupied less than two months. The LeTourneau factory itself, and a number of houses for the employees, were similarly constructed.

The welding equipment used was supplied by Messrs. The Lincoln Electric Company, Limited, Welwyn Garden City, who were similarly associated with an interesting example of welded construction carried out by the LeTourneau Corporation, namely the fabrication of a 700-ton toggle press for the production of the steel blocks and panels used in building this new type of house. Successive stages in the construction of the press, which took only 35 days from the original rough design to the finished product, are shown in Figs. 2 to 4, on the opposite page, and Figs. 5 to 8, on page 350. Four welders and one "set-up man" completed the whole of the welding in 3½ days. The principal factor contributing to the very considerable saving of time which this result represents was the reduction in machining time by comparison with other methods of manufacture. The general design of the press can be seen from Figs. 2 and 3, opposite, which show it, respectively, in process of assembly and after completion. The press was made entirely from standard rolled sections and plates, flame-cut to practically the exact sizes and welded together; there was very little excess metal to be removed by machining. The simplicity of this method of construction permitted a reduction of 26 per cent. in machining time and, incidentally, released the machine-tools for other work to a corresponding extent.

The crankshafts, one of which is shown in Fig. 4, opposite, were cut from 6-in. plate with a pantograph cutting machine, and the links were cut from 6-in. flat bar. The only machining required to complete these parts was on the bearing surfaces. Drilling of the links was confined to giving a machined finish to holes previously flame-cut approximately to size. After its component members had been tack-welded into position, as shown in Fig. 5, on page 350, the base was tilted so that the permanent welding could be carried out in the flat position, thus enabling the welding to be done at the highest possible speed, using the largest-diameter electrodes. This stage is illustrated in Fig. 6, on the same page, which also shows the 8-in. billets used for the slide guides and end sections. For the other parts

ALL-WELDED PRESS FOR STEEL BUILDING BLOCKS.

MESSRS. THE LETOURNEAU CORPORATION, PEORIA, ILLINOIS, U.S.A.

FIG. 2. ASSEMBLING 700-TON PRESS.

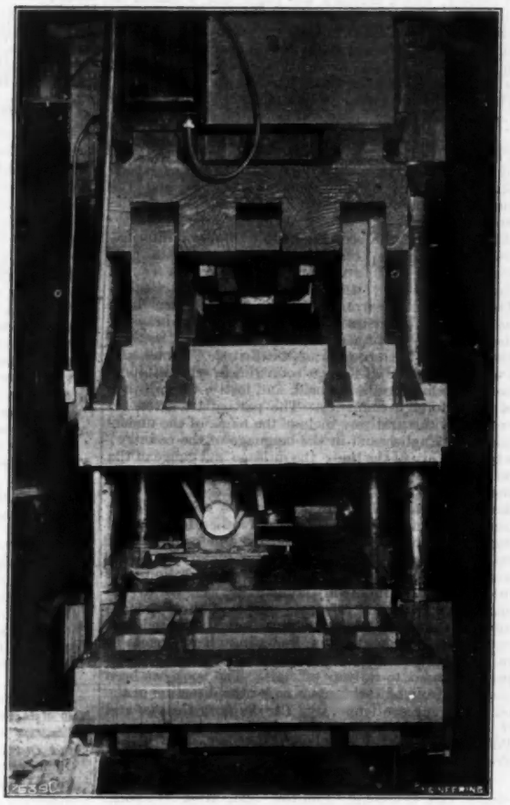


FIG. 3. PRESS COMPLETED.

FIG. 4. CUTTING PARTS FROM 6-IN. PLATE.

forming the base plate, 3 in. in thickness, was employed. Fig. 7, on page 350, shows all the main structural parts of the press, these being numbered as follows: (1) right link; (2) crown; (3) and (4), right and left crankshafts, respectively; (5) (partly obscured by one of the operators) left link; (6) ram; and (7) base. Oil seal rings were welded to the crankshafts before machining. The base is also shown in Fig. 8; planing has been completed, and the holes are being bored in the 8-in. billets for the tie rods and guides. It should be mentioned that the various gear-wheels in the drive to the crankshafts were also fabricated by arc welding. In addition to the saving in construction time, previously referred to, the use of welding enabled a considerable amount of material to be saved, by comparison with the more usual methods of press construction, without any reduction in strength; and as standard steel sections were employed throughout, there were no "bottlenecks" in the supply of material or of component parts. Welded fabrication of this type, it is stated, is now being extended to the manufacture of many machine tools, both of standard types and for special purposes; and the method is found to afford a greater freedom in design and to permit more readily of alterations in design than the procedure hitherto regarded as orthodox.

ANNUALS AND REFERENCE BOOKS.

Anglo-American Year Book, 1941.—The American Chamber of Commerce in London, Bush House, Aldwych, London, W.C.2., issues this useful little year book to its members, but it is also available to the general public at the price of 15*s.* net. The volume opens, with a list of members of the Chamber, and the following section gives particulars of American societies in Great Britain. Other chapters of interest relate to such subjects as British and American patent law, American Consular invoice and passport regulations, English law for Americans, and American law for Britons. The concluding sections comprise a directory of Americans resident in the British Isles, a commercial directory of firms carrying on business in the British Isles and in the United States arranged alphabetically, and a classified list of trading and professional firms engaged in business in both countries, either through agents or branch houses. The year book, which is edited by Miss E. Clunas, comprises 500 pages, and is well printed and bound.

British Engineers' Association Handbook, 1941.—The main object of the compilers of the annual classified *Handbook* of members of the British Engineers' Association and their products is to establish a closer contact between buyers overseas and the engineering firms which are members of the Association. An account of the activities of the Association is first given, and an alphabetical list of the members

and their addresses, together with particulars regarding their manufactures and products, and the codes they employ in correspondence, is then given. The longest section of the volume, which occupies nearly 200 pages, is occupied by publicity matter furnished by member firms. The last section consists of a classified list of the manufactures of member firms. The 1941 *Handbook*, which includes 450 pages and is bound in stiff paper covers, constitutes the twelfth annual edition. We are asked to state that copies of it will be sent free, and postage paid, to applicants who could make good use of the publication, if a written request is made on a business letter heading to the Director, The British Engineers' Association, 32, Victoria-street, London, S.W.1.

Universal Directory of Railway Officials and Railway Year Book.—The 47th annual edition, that for 1941-42, of this well known work of reference has recently been published. The continuation of the war and the outbreak of further hostilities in various parts of the world has increased the task of the compilers. Nevertheless, while it has been impossible to obtain information directly from certain regions, more data concerning many of the world's railways have been secured than was at one time thought to be practicable. The geographical arrangement of the data has been preserved. The first section relates to the railways of the British Isles; then follow, in sequence, sections dealing with the railways of the British Colonies and Dominions, those of foreign countries in which important British interests are held, and lastly, the railways of other foreign countries. The particulars given for each individual railway include the name of the undertaking in English and in the language of the country; a brief history of the line; the mileage and gauge of the railway; the locomotives and rolling stock owned; the names of the directors and principal officers; and financial data. The year book section of the volume contains a mass of statistical and other information regarding the history, organisation and operation of railways which, in common with the remainder of the work, has been thoroughly revised. This section is of interest to the inquiring layman as well as to the engineer. For ready reference purposes, three indexes are given at the end of the volume, namely, an index to countries; a general index, including all references to railways and statistical and other information; and a personal index to railway officials. The book has been compiled from official sources under the direction of the editor of our contemporary, *The Railway Gazette*, and it is obtainable, price 1*l.* net, from the Directory Publishing Company, Limited, 33, Tothill Street, Westminster, London, S.W.1.

Directory of Paper Makers.—Messrs. Marchant Singer and Company, Limited, 326, High Holborn, London, W.C.1, have recently published the 1941, or 65th annual, edition of the *Directory of Paper Makers of Great Britain and Ireland*. As has been the case with previous editions, the volume first gives an alphabetical list of paper and millboard makers in Great Britain and Ireland, in which brief data regarding the chief products and the number of machines in use are furnished, as well as the postal and telegraphic addresses, the telephone numbers, and the names and addresses of agents in London and other centres. A similar list is then given of paper enamellers, surfacers and gummers, and of manufacturers of foil, waxed and transparent papers, and of pasteboards, pulpware and other materials. Shorter lists of paper makers' representatives and paper agents, London wholesale stationers, paper stock dealers, waste-paper merchants, and producers and merchants of China clay are also included. Other sections comprise an interesting chapter on paper-trade customs, data on the standardisation of papers and boards, British Standard sizes of paper, alphabetical and geographical lists of individual paper mills, lists of officers of paper and allied trades associations, and a section on watermarks and trade names. The more important sections of the book have been thumb indexed to facilitate quick reference. The price of the volume is 6s. net.

The Furniture Beetle.—Leaflet No. 8, dealing with the common furniture beetle, has just been issued in revised form by the Forest Products Research Laboratory. This insect, associated in most people's minds with antique furniture, is more ubiquitous than is generally recognised and is capable of causing considerable damage to rafters, joists, floor boards, and other structural timbers in buildings. The importance of avoiding the necessity for renewals of woodwork under present conditions is great and the leaflet, by enabling the insect to be identified and by drawing attention to means for preventing its spread and of eradicating it, is likely to be of service. Copies of the leaflet may be obtained free of charge from the Director of the Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks.

INSTITUTION ELECTIONS.

Institute of Transport.

Member.—Sir K. G. Mitchell, C.I.E., Delhi, India.

Associate Member.—R. Barr, Leeds; W. H. Brassington; S. A. Carter; N. D. Cooper; A. B. Davidson; L. Dawson, Liverpool; A. R. Dunbar, Leeds; N. F. Haigh, Darwen; J. M. Hanna, Nottingham; L. C. Harrison, Portsmouth; H. Hoffman; H. Mann, Bradford; N. McDonald, Stockton-on-Tees; E. A. C. Player; S. Smith, Stoke-on-Trent; R. B. Temple, Leeds; E. H. Thomas; D. Vine; J. H. Wakefield, New South Wales; L. Walker, London.

Institution of Civil Engineers.

Associate Member to Member.—Henry William Flett, Pahang, Malaya; Robert Hugh Stannus Howell, B.Sc. (*Eng.*) (Lond.), London, S.W.1.

BOOKS RECEIVED.

"*The Electrician*" *Annual Tables of Electricity Undertakings*, 1941. London: Benn Brothers, Limited. [Price 12*s.* 6*d.* net.]

United States Bureau of Mines. Bulletin No. 434. *Contributions to the Data on Theoretical Metallurgy.* IX. *The Entropies of Inorganic Substances. Revision* (1940) *of Data and Methods of Calculation.* By K. K. Kelly. Washington: Superintendent of Documents. [Price 15 cents.]

United States National Bureau of Standards. Building Materials and Structures. Report BMS72. *Structural Properties of "Precision-Built, Jr." Prefabricated Wood-Frame Wall Construction, Sponsored by the Homasote Company.* By A. H. Easton and M. F. Peck, with the collaboration of R. F. Luxford. Washington: Superintendent of Documents. [Price 10 cents.]

South Africa. Electricity Supply Commission. Eighteenth Annual Report of the Electricity Supply Commission for the Year Ended 31st December, 1940, with a Brief Review of Its Activities up to 31st March, 1941. Escom House, Rissik-street, Johannesburg: Offices of the Commission.

The Manchester Association of Engineers. Transactions. Session 1940-41. Edited by T. Makemson, Secretary, and J. Bolton, Assistant Secretary. St. John-street Chambers, Deansgate, Manchester, 3: Offices of the Association.

New Methods for Sheet Metal Work. A Practical Working Textbook for Apprentices, Sheet Metal Workers, Platers and Draughtsmen. By W. Cookson. "Piccancot," Gloucester-road, Kingston Hill, Surrey: The Technical Press Limited. [Price 7*s.* 6*d.* net.]

Engineering Workshop Manual. Containing Practical Information on Micrometers, Verniers, Tools, Fitting, Screw-Cutting, Workshop Arithmetic, Geometry, Mensuration, Gear-Cutting, Capstan and Turret Lathes, Precision Grinding, General Machine Work and Blueprint Reading. By E. Pull. Ninth edition, revised and enlarged. "Piccancot," Gloucester-road, Kingston Hill, Surrey: The Technical Press, Ltd. [Price 5*s.* net.]

Simple Hydraulics for Firemen. By E. D. Grubb. 12, Small-street, Bristol, 1: J. W. Arrowsmith (London) Limited. [Price 1*s.* 6*d.* net.]

"*Mechanical World*" *Monographs.* No. 11. *Fire Engineering Hydraulics.* By G. O. Stevenson. 78, Palatine-road, Manchester, 20: Emmott and Company, Limited. [Price 1*s.* net.]

Post-War Questions. No. 7. *The Socialists' "New Order."* By Professor F. J. C. Hearnshaw. London: The Individualist Bookshop, Limited, 154, Fleet-street, E.C.4. [Price 6*d.* net.]

The Institute of Welding. Welding Ships. A Bibliography of Books, Pamphlets, Abstracted Periodicals and Press Cuttings, Covering the Period 1931 *to* 1941. London: Offices of the Institute, 2, Buckingham Palace-gardens, S.W.1. [Price 3*s.*]

India. Central Board of Irrigation. Publication No. 24. *Annual Report* (*Technical*) *of the Central Board of Irrigation, India*, 1939-40. Edited by A. R. B. Edgecombe, Secretary. Simla: Offices of the Board.

Engineering Kinematics. By Professor Alvin Sloane. New York: The Macmillan Company. London: Macmillan and Company, Limited. [Price 17*s.* net.]

Licences for the Control of Exports.—Under a Board of Trade Order, which comes into force on November 6, licences will be required to export, to all destinations, a number of additional forms of iron and steel (including alloy steel) and articles manufactured wholly or mainly of iron or steel. The Order (S.R. & O. 1941, No. 1615) also prohibits the export, except under licence, of neoprene and manufactures thereof, and extends the existing prohibitions relating to machine and other tools, paper-insulated wire and cables, mining drill bits, borax, boric acid and certain types of railway locomotives and vehicles.

PERSONAL.

Mr. William Shearer has been elected a director and appointed chairman of the Perak River Hydro-Electric Power Company, Limited, in succession to the late Mr. George Balfour, M.P.

Mr. O. R. H. Bury, deputy chairman of the London Power Company, Limited, has succeeded the late Mr. George Balfour, M.P., as chairman. Lord Lytton has been appointed deputy chairman.

Mr. William Nithsdale, formerly a director of Messrs. Yarrow and Company, Limited, Glasgow, has recently been appointed to the board of directors of Messrs. Richardsons, Westgarth and Company, Limited, Wallsend-on-Tyne.

Mr. J. L. Brown, hitherto senior executive engineer, has now been made director of public works, Fiji. Mr. H. E. Smythe has been promoted from the position of executive engineer to succeed Mr. Brown as senior executive engineer.

Mr. W. C. Lusk has been elected chairman of Messrs. Ferguson, Pailin, Limited, Higher Openshaw, Manchester, 11.

Major C. Alderson, D.S.O., has been appointed assistant director of Public Works, Gold Coast, West Africa.

Mr. W. E. Hobbs, Companion I.E.E., district manager General Electric Company, Limited, Cardiff, has retired after nearly 50 years' service with the company. His successor is Mr. H. B. Druce.

Mr. G. V. Stanway has been elected President of the Stoke-on-Trent Association of Engineers. He is a director of Messrs. Howells (Electric Motors), Limited, Vale Place Works, Hanley, Stoke-on-Trent.

Mr. R. H. Shreve, of Washington, D.C., U.S.A., has been elected an honorary corresponding member of the Royal Institute of British Architects, 66, Portland-place, London, W.1.

Mr. J. W. Parker, vice-president and chief engineer of the Detroit Edison Company, has been elected President of the American Society of Mechanical Engineers for 1942. Messrs. C. F. Freeman, C. B. Peck, W. H. Winterrowd and W. R. Woolrich have been elected vice-presidents, and Messrs. W. G. Christy, H. L. Eggleston and T. S. McEwan managers of the Society. The new officers will be installed during the 62nd annual meeting to be held at New York from December 1 to 5.

Mr. Paul Gilbert, who has been director of building programmes in the Ministry of Works and Buildings since the creation of that position, has found it necessary to tender his resignation owing to his firm's urgent commitments on work of national importance. He will continue to serve on the Central Council Works Committee.

NOTES FROM THE SOUTH-WEST.

Cardiff, Wednesday.

The Welsh Coal Trade.—Little new business could be negotiated in any section of the Welsh steam-coal market during the past week. Salesmen had sufficient orders on their books to provide a steady outlet for potential productions of the more popular sorts for some time to come and the tone was consequently very firm. Despite the conservation of supplies for the inland market and the efforts made to increase the output of the district, the demand continued to exceed the supply and most collieries held sufficient orders on their books to ensure the maintenance of these conditions for a considerable time. Best large descriptions continued to find a ready outlet in contract deliveries, and a very firm tone ruled in the sized kinds, which experienced a sustained demand and were not easily booked forward. An acute scarcity of the bituminous small grades caused these to form the strongest feature of the market and the occasional odd lots that became available found ready outlets at recent high prices. On the other hand, little difficulty was experienced in obtaining early deliveries of the dry steam small sorts which attracted little attention and were consequently dull. Cokes were in brisk request from home users, but were scarce and strong.

The Iron and Steel Trade.—Conditions in the various branches of the iron and steel and allied trades of South Wales and Monmouthshire showed no change.

Institution of Heating and Ventilating Engineers.—The publicity and journal committee of the Institution of Heating and Ventilating Engineers are anxious to obtain papers from members and others for publication in the *Journal* of the Institution. The Council has agreed to continue the offer of premiums, up to 10*l.* 10*s.*, for papers on subjects of interest to the profession, and the offer is open both to members and non-members. Papers, complete with tables and illustrations, should be sent to the Acting Secretary of the Institution, 21, Tothill-street, London, S.W.1, and it should be stated whether the author wishes it to be considered for the premium or not.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Although it is difficult to assess the progress that is being made by the many branches of the steel and engineering trades of this area, it is safe to state that the gross output exceeds the figure reached during the last war. Sheffield firms, however, are still transacting a steady volume of commercial business. Export trade is very restricted, though every effort is being made to maintain contact with overseas customers. The tonnage of basic steel being produced is exceptionally large, and acid-steel makers are also accounting for a substantial tonnage. The consumption of steelmaking alloys has increased considerably owing to the heavy demand for high-efficiency steels. Scrap merchants are handling larger tonnages, and users have little difficulty in obtaining adequate supplies. Progress in the heavy-machinery and engineering branches has been well maintained. The demand for steelworks plant is particularly heavy; orders are in hand for a large variety of equipment, including rolling mills, forges, presses, steam hammers, etc. In sections devoted to the production of ship steel, forgings and castings, activity has become more general. Sheffield-made plant for the quarrying industry is being used more extensively, and a limited amount of overseas trade is being done in boring machines, washing and refining equipment, dredger gear and parts. Coal-mining requirements are increasing, the most active lines being steel props and coal-cutting machines. In other directions Sheffield works are benefiting from developments requiring the use of elevators, trench diggers, tractors and excavators. Electrical equipment remains one of the most important and progressive sections. Makers of agricultural machinery and parts are active, as are also the tool-making branches; outputs of all types of engineers' small tools have attained a high level.

South Yorkshire Coal Trade.—Business in all classes of coal is brisk. Industrial requirements are increasing, and steelworks and ironworks are acquiring large stocks; smalls and slacks are moving freely. Locomotive coal is steady, and the house-coal market displays seasonal activity. There is a steady call for foundry and furnace cokes.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—During the past week there has been no reduction in activity in the Scottish steelworks and managements are being hard pressed to supply the requirements of their clients, who are mainly engaged on Government work. The shipyards being very busy, there is a steady consumption of plates, etc. Light plates and sections are moving freely, and there is an increasing call for special high-grade steel. Makers of black-steel sheets are fully employed. Prices are unchanged, and are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—Fairly satisfactory conditions now prevail in the West of Scotland malleable-iron trade and most plants are fully employed, but raw materials are still rather scarce. The re-rollers of steel bars are able to undertake more work, although they are fairly busy. Good stocks of semies are now held. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—No change in the position can be reported in the Scottish pig-iron trade and all material available is delivered promptly to consumers. The demand for hematite is particularly strong, and all the present output is utilised for Government work. Basic iron is also active, but foundry grades are still somewhat dull. To-day's market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' works.

APPROVED ELECTRODES FOR ELECTRIC ARC WELDING.—The British Corporation Register of Shipping and Aircraft, 14, Blythswood-square, Glasgow, has issued a new list of approved electrodes for electric arc welding. The particulars given include the names of the makers and of the electrodes and the distinctive markings whereby the latter may be distinguished. Any limitations imposed on the use of any particular electrode are also indicated.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—As all transactions in iron and steel have to be officially approved, attendances on the exchange have been reduced considerably. Notwithstanding this the volume of business passing is considerable. Outputs of most commodities are near the maximum and supplies of most products are taken up as soon as they become available for distribution. Raw and semi-finished materials are abundant, forge and foundry pig are in ample supply, and deliveries of finished products are sufficient for essential requirements; supplies of hematite iron, however, are still somewhat below current needs.

Cleveland Iron Trade.—Regular and ample deliveries of Midland foundry iron are quite sufficient to compensate for the shortage of Cleveland pig. There is still no prospect of any material increase in the production of the latter. Consumers of foundry iron have no difficulty in purchasing from producers quantities which are sufficient for their needs. The fixed market prices of Cleveland pig remain at the equivalent of No. 3 quality at 128*s.* delivered to local buyers.

Basic Iron.—The nominal quotation of basic iron remains at 120*s.* 6*d.* Makers have none for sale, but are maintaining the output at a level which covers the heavy requirements of their own steelworks.

Hematite.—The position regarding hematite shows no change. The official values are ruled by No. 1 grade of iron at 138*s.* 6*d.* delivered to North of England customers.

Blast-Furnace Coke.—The situation in the Durham blast-furnace coke branch of trade is fairly satisfactory though buyers and sellers are disinclined to discuss business. Prices are firm at the level of good medium qualities at 36*s.* 9*d.* f.o.r.

Manufactured Iron and Steel.—The tonnage of semi-finished iron and steel stored is very substantial, but the consumption is heavy and stocks are being drawn upon. Re-rollers hope to keep their reserve supplies at a satisfactory level by obtaining increased deliveries from home producers. In the finished industries pressure for delivery is greatest for ship, tank and boiler plates, black and galvanised sheets and special alloy steels.

Scrap.—All grades of heavy iron and steel scrap are in strong demand but light varieties are less urgently needed.

SPECIFICATION FOR BERYLLIUM-COPPER ALLOY.—The American Society for Testing Materials has recently approved as a new standard specification No. B120-41T for beryllium-copper alloy bars, rods, sheet, strip and wire. The specified beryllium content of the alloy lies between 1·90 per cent. and 2·20 per cent.; the maximum percentages of added elements and of impurities are 0·50 in each case; the remainder of the alloy consisting of copper. The physical requirements vary according to the heat treatment given and to the nature of the product. The tensile strength of sheet and strip material ranges from 32·6 tons to 42·5 tons per square inch, but that of material in the precipitation-hardened condition ranges from 67 tons to 80 tons per square inch.

STAINLESS-STEEL SHEETS IN OIL-REFINING INDUSTRY.—Writing in a recent issue of the *Welding Journal*, Mr. R. L. Looney advocates the use of stainless-steel sheet for lining bubble towers in oil refineries in order to increase their resistance to corrosion and oxidation. He quotes one instance of a tower which was lined with 18-8 steel No. 10-gauge sheets, measuring 6 ft. by 2 ft., and electrically welded with ⅛ in. 18-8 steel electrodes. The method recommended at present, however, is to employ No. 10-gauge 4 per cent. to 6 per cent. chromium-steel strips, measuring 30 in. by 4 in., and placed at an angle of 45 deg. to the horizontal, and to weld these to the wall of the tower by applying three beads with electrodes of 18-8 stabilised steel.

FIRE WATCHERS' LOG BOOKS.—Messrs. Herbert Fitch and Company, Limited, printers and stationers, 31-35, Mansell-street, Aldgate, London, E.1, have sent us copies of two fire watchers' log books which they have prepared and issued recently. The smaller of the two books is intended for business premises, having a maximum of eight watchers per day. It contains 120 pages and the price is 3*s.* 6*d.* net. The larger book has spaces for 30 watchers per day. It is intended for area or zone schemes, or for large firms, factories and institutions, and contains 328 pages. Its price is 10*s.* net. Both books contain ruled pages for addresses, standing rules, and lists of equipment, in addition to pages for rotas, duty hours, watchers' reports, etc., while printed instructions on gas and its detection, fire-fighting methods, and other matters of importance to fire guards are also included. The log books are printed in a form approved by the Corporation of London.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—To-night, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. Andrew Laing Lecture: "Merchant Sea Power, 1919 to 1939," by Sir Westcott Abell. *Student Section:* Saturday, November 8, 2.30 p.m., Bolbec Hall, Newcastle-upon-Tyne, 1. "The Elements of Aerodynamics and Some Points of Contact with Naval Architecture," by Dr. F. H. Todd.

KEIGHLEY ASSOCIATION OF ENGINEERS.—To-night, 8 p.m., The Victoria Hotel, Keighley. Lecture: "A Breakdown and the Technicians Who Made Possible the Repair," by Dr. J. Prentice.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, November 1, 2.30 p.m., The College of Technology, Manchester. Joint Meeting with THE MANCHESTER TECHNOLOGY OLD STUDENTS' ASSOCIATION. "The Water Grid," by Mr. A. E. L. Chorlton.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, November 3, 6 p.m. The James Watt Memorial Institute, Birmingham. "Space-heating by Means of Electrically-warmed Floors in Air-Raid Shelters," by Mr. R. Grierson. *Wireless Section:* Wednesday, November 5, 4 p.m., Savoy-place, Victoria-embankment, W.C.2. Inaugural Address by the Section Chairman, Mr. H. Bishop. *South Midland Students' Section:* Wednesday, November 5, 6.30 p.m., The James Watt Memorial Institute, Birmingham. Problems Evening. A number of informal discussions. *Meter and Instrument Section:* Friday, November 7, 4 p.m., Savoy-place, Victoria-embankment, W.C.2. Inaugural Address by the Section Chairman, Mr. W. Phillips. *North-Western Centre:* Saturday, November 8, 2.30 p.m., The Engineers' Club, Albert-square Manchester. (i) "The Control of the Domestic Load," and (ii) "The Optional Control System of Domestic Supply," by Mr. P. Schiller.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 4, 2 p.m., Great George-street, Westminster, S.W.1. Presidential Address, by Professor C. E. Inglis. *North-Western Association:* Saturday, November 8, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. "Road Experiments on the Design of Thin Bituminous Surfacings," by Mr. Robert Slater.

ROYAL SOCIETY OF ARTS.—Wednesday, November 5, 1.45 p.m., John Adam-street, Adelphi, W.C.2. "Co-Operation for Production," by Sir Edward Crowe.

BRITISH ASSOCIATION OF REFRIGERATION.—Thursday, November 6, 3 p.m., The Institution of Mechanical Engineers, Storey's Gate, St. James's Park, Westminster, S.W.1. Presidential Address, by Dr. S. F. Dorey.

INSTITUTE OF TRANSPORT.—*Metropolitan Graduate and Student Society:* Saturday, November 8, 2.15 p.m., The Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. "Basic Principles of Schedules for Road Passenger Transport," by Mr. H. F. Adcock.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, November 8, 2.30 p.m., 39, Victoria-street, Westminster, S.W.1. Informal Meeting. "Mills and Mill Gearing," by Mr. Rex Wailes.

THE AMERICAN PETROLEUM INDUSTRY.—The output of crude oil in the United States continues at a high level, the daily production during the week ended October 11 averaging 4,071,000 barrels, against 3,861,000 barrels in the preceding week.

INSTITUTION OF NAVAL ARCHITECTS.—The Council of the Institution of Naval Architects have announced the award of a number of scholarships in naval architecture and marine engineering for the year 1941. The Sir William White Post-Graduate Scholarship in naval architecture, valued at 150*l.* per annum and tenable for two years, has been gained by Mr. A. Silvericaf, B.Sc., of Glasgow University. The Institution of Naval Architects Scholarship in Naval Architecture, worth 130*l.* per annum, has been awarded to Mr. G. J. Boulter, of H.M. Dockyard, Portsmouth, and will be held at the Royal Naval College, Greenwich, for three years. Mr. K. G. Evans, also of H.M. Dockyard, Portsmouth, has won the Earl of Durham Prize. The Vickers-Armstrongs Scholarship in Naval Architecture, which has a value of 150*l.* per annum, has been awarded to Mr. J. T. Tothill, of Barrow-in-Furness, who will hold it for four years at Glasgow University. The Denny Scholarship in Naval Architecture has been gained by Mr. C. A. Lyster, of Harrow School, and the Denny Scholarship in Marine Engineering by Mr. Horner McCririck, Jun., of Bromsgrove School. Both scholarships are of the value of 100*l.* per annum and will be held at Glasgow University for four years.

ALL-WELDED 700-TON PRESS FOR STEEL BUILDING BLOCKS.

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(*For Description, see Page* 346.)

FIG. 5. BASE WITH PARTS TACK-WELDED.

FIG. 6. WELDING THE BASE.

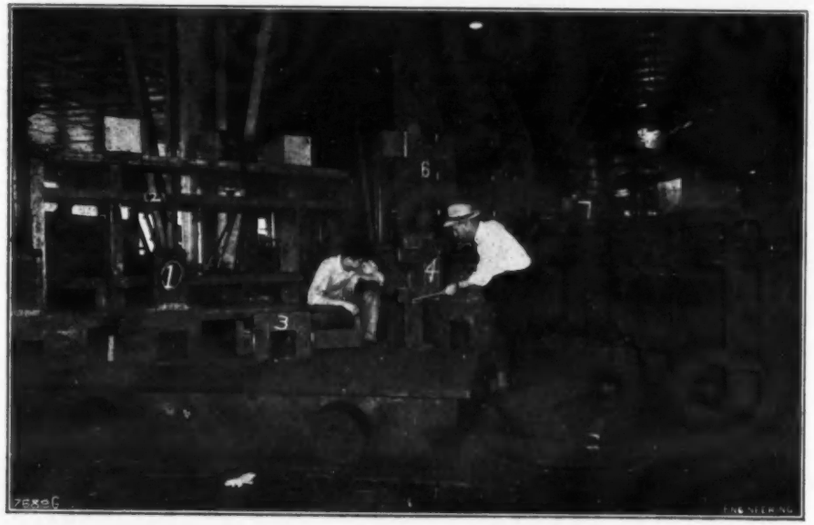

FIG. 7. MAIN STRUCTURAL PARTS OF PRESS.

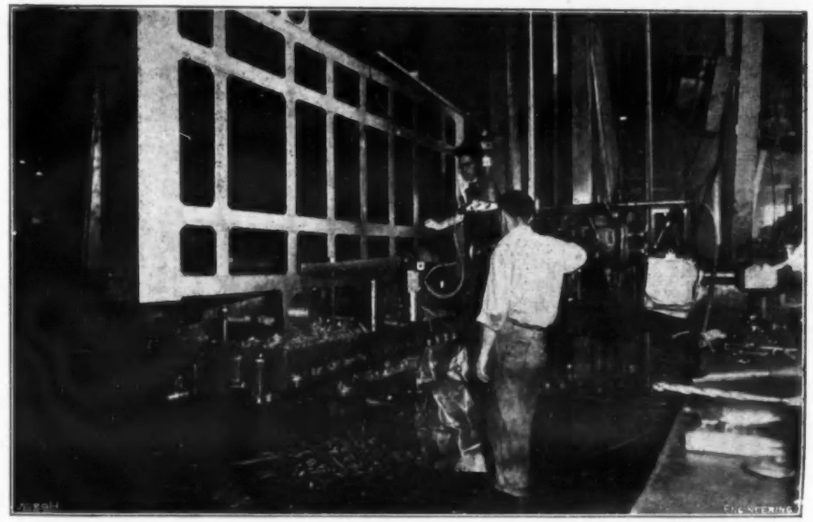

FIG. 8. BORING HOLES FOR TIE RODS AND GUIDES.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730 and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, OCTOBER 31, 1941.

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THE STEAM LOCOMOTIVE.

So far as an institution of more than 14,000 members can be said to have a collective bias, that of the Institution of Mechanical Engineers is undoubtedly in the direction of locomotive engineering. Whether this is a natural development from the fact that it was founded by locomotive and railway engineers, or is an enduring tribute to George Stephenson, the first president, is a matter for conjecture ; it seems possible, if not probable, that the real reason is even more deeply rooted in human nature, for which the locomotive has always exerted a fascination shared by few, if any, other forms of mechanism. It is easy to scoff that "men are but children of a larger growth"—to which a fitting retort would be that "the child is father of the man" ; the fact remains that the Institution's meeting room at Storey's Gate is never so well filled as when there is a locomotive-engineering paper to be presented. The presidential address delivered on October 24 by Mr. W. A. Stanier served to emphasise once more this well-known phenomenon. The devotees were not disappointed in their expectations that not even the exigencies of war and the operations of censorship would rob this subject of its professional and popular interest.

Not all of the eleven locomotive engineers who, as Mr. Stanier recalled, have occupied the chair founded by George Stephenson have recognised, in their choice of a subject for a presidential address, that it is the locomotive which, after all, is the *fons et origo* of the interest that railway engineering inspires. John Ramsbottom, for example, delivered no address during his presidency in 1871, though he did read two papers on the ventilation of railway tunnels. To come to the present century : S. W. Johnson of the former Midland Railway, discussed railway progress in general terms ; T. Hurry Riches dealt with British railway rolling stock ; Sir John Aspinall, in 1909, spoke on railway electrification, then assuming some topical interest, and recently exemplified in practice by his electrification of the Southport line of the Lancashire and Yorkshire Railway. Sir Vincent Raven, sixteen years later, concentrated on the economics of railways, with particular reference to the development of Australia and New Zealand, where he had just completed a tour of inspection in a consulting capacity ; and Sir Henry Fowler confined his attention to practical problems of metallurgy. Only with the presidency of the late Sir Nigel Gresley, in 1936, did the locomotive, *per se*, really come into its own ; now to be confirmed as a focus of engineering interest by Mr. Stanier's survey of recent progress and of the progress yet to be made.

In the substance of the last two addresses, namely, Sir Nigel Gresley's on modern high-speed locomotives, and Mr. Stanier's on "The Position of the Locomotive in Mechanical Engineering," may be found a possible reason for the seeming reluctance of former locomotive-engineer presidents to discuss what would seem the obvious department of engineering progress ; for these two addresses make abundantly clear the very modest rate that has characterised locomotive development until comparatively recent years. The overall thermal efficiency of 5·2 per cent., on an indicated horse-power basis, which is all that Mr. Stanier credited to a typical saturated-steam locomotive of the 'eighties, can represent relatively little improvement over the practice of forty years earlier, when railways were emerging from the purely experimental stage. That this efficiency should have been more than doubled in the past 50 years seems to indicate a very gradual rate of improvement ; and in fact the greater part of that improvement, and certainly the more difficult part to attain, has been accomplished within the past twenty years only. One main reason why the locomotive-engineer presidents of the Institution did not devote more of their addresses to this branch of mechanical engineering, therefore, would appear to be the lack of any material advances to provide them with suitable texts.

Mr. Stanier adduces several reasons to account for the general failure to seek more urgently some increase in the average level of thermal efficiency in the period between the broad stabilisation of types, in the mid-Nineteenth Century, and the developments initiated by Churchward, on the Great Western Railway, in the early years of the Twentieth. In the first place he sets the prevalence of cheap fuel and the absence of any spur to action from alternative forms of transport. The lack of any exact means of measurement and comparison, and the existence of so many small self-contained railway systems, tended to concentrate the attention of railway mechanical engineers upon reliability in operation—or, perhaps he might have said, the reduction of maintenance charges—rather than upon the betterment of thermal efficiency. The effect was to discourage developments which might be regarded more critically in the light of departures from established practice, rather than as the basis for a new and better practice. In this respect, there can be little doubt that the policy of grouping the railways into the four main systems, which induced a certain amount of criticism at its inception, twenty years ago, has been beneficial in its effect upon locomotive design, by the opportunities that it afforded both for the elimination of old and notably inefficient types and for the introduction of more long-distance services in which new types could be employed to the best advantage.

The case of the London Midland and Scottish Railway, cited in Mr. Stanier's address, pointedly illustrates the benefits that were rendered possible by the concentration of the component lines, each reckoned important in its day, under a unified direction, able to command the funds necessary to follow out a bold policy of technical improvement. At the present time, he stated, 2,000 engines on that system have cylinders of modern design and long-lap valve gear, as against only 25 in 1923. Of the total locomotive stock, 56 per cent. is now superheated ; and the engines working the heaviest services—the Scotch expresses—show a reduction of 40 per cent. in coal consumption per drawbar horse-power, compared with the best available in 1926. It would be easy to use such figures as an excuse to belittle the work of the railway mechanical engineers of the pre-grouping era, or as arguments in favour of a more extensive grouping of the present railway systems into still larger units, or even into a single organisation covering the whole country ; but it does not follow that such arguments would be justified. Certainly, many of the contributory improvements would have been quite practicable,

though applied on a smaller scale, many years before the railway amalgamation of 1922—as, indeed, Churchward and other pioneers demonstrated in the case of some of them; but it is by no means certain that the overall economies achieved would have been commensurate with those recorded by Mr. Stanier. It is one thing to have a machine capable of a certain optimum performance, but quite another to provide it with opportunities to realise that optimum in ordinary service, under conditions so different from those of the present day as were those of the pre-1914 years. The period from 1914 to 1921, obviously, can hardly be taken into account in such a comparison.

The use of the record of post-grouping technical development as an argument in favour of a further amalgamation, if any serious student of railway economics should be tempted to employ the figures in such a way, would be to ignore certain fundamental considerations. For one thing, no more comprehensive grouping scheme could greatly extend the opportunities for through running, which provide some of the most favourable occasions for maintaining an efficient locomotive performance. In the second place, and apart from the natural limitations imposed by materials, thermodynamics, and the human factor, the margin for further technical improvement cannot continue to be reduced without encroaching upon purely economic influences which may easily absorb and perhaps overweigh the potential benefits. The hypothetical case postulated by Mr. Stanier may be quoted. If careful testing indicates that an alteration costing 200*l.* per engine will save 50*l.* per annum in coal, and 20,000*l.* is spent in modifying 100 engines accordingly, the expected financial saving may yet be completely negatived by some variation in traffic conditions, such as a revival in trade, calling for heavier train loadings, or a new timetable involving higher overall speeds. It is conceivable that further amalgamation, requiring extensive reorganisation of the whole machinery of management, might impose new administrative burdens as a direct result of what might appear, from the public viewpoint, to be a considerable simplification; and that these would nullify the advantages of some technical developments to which, on the surface, they bear no obvious relationship.

The establishment of the new locomotive-testing plant, to be operated jointly by the London Midland and Scottish Railway and the London and North Eastern Railway, appears to typify a policy of collaboration that is likely to be more fruitful in the long run than a complete amalgamation could be, in promoting the future technical development of steam-locomotive design in this country. The total area of Great Britain may not be large, but it is large enough to put considerable obstacles in the way of attempts to reduce its locomotive needs to a common formula. The layout of the main railway systems has not been quite so fortuitous as a glance at the map might suggest; primarily, they link the great industrial areas, and these in turn owe their rise to natural conditions which fundamentally affect the railways and their operation—for example, the existence of the coal beds, containing coal of widely differing character, which the locomotives in those districts must be designed to use. Differences in the quality of the water available have also a direct bearing on the cost of operation; and, although the wider adoption of water-softening plants has overcome this disability to some extent, provision of these plants also influences railway economics, apart from the effect on boiler maintenance and locomotive availability. In general, the development by each system of the types suited to its own needs, under the technical control that the new testing plant should greatly facilitate, appears to be the most logical course to pursue. If, in the course of time, it proves practicable to devise some composite designs of even wider utility than those now existing, a narrower standardisation of types may follow, and might even be extended to the provision of certain classes that could be common to two or more railways; but there seems reason to doubt whether an amalgamation of any or all of the present main-line systems would in itself greatly reduce the number of locomotive types now in service, or raise their average of efficiency.

THE UNIFICATION OF TRANSPORT CONTROL.

In the course of a debate in the House of Commons last week on the new railway agreement, two speakers contended that Government control of transport should be extended and intensified. One stated that "the transport services required complete unification without delay," and the other that "much larger unification of transport control . . . was essential." We do not know if these members have worked out procedures by which this unification could profitably be carried out, but it is pertinent to point out that the Royal Commission on Transport, which sat for more than two years and took evidence from every responsible association and individual concerned with transport with which they were able to get into touch, were unable to recommend any method by which this complete unification could be carried out. In their final report, published in 1931, they discussed nationalisation, rationalisation, a combination of these, or the formation of a public trust. They were not, however, able to recommend any of them. If this authoritative body considered the difficulties such as to render unification impracticable in times of peace, it would hardly appear desirable to plunge in war time into the administrative and financial mælstrom which would result.

Lay opinion on this subject is apt to be misled by tacitly assuming that procedure applicable to railways can be extended to road traffic and shipping. Railways are a simple case. They are organised in five main groups which have close interworking arrangements, and the placing of the whole system of the country under Government control has involved negotiations and arrangements with what is, in effect, a single unified body. As against the five railway groups, road transport is carried on by hundreds of independent bodies having widely different interests and carrying on very varied types of business. Due to the activities of the Royal Commission on Transport, conditions are less chaotic than when the evidence was taken, and it was the recommendations of the Commission which led to the present licensing arrangements and the appointment of the Regional Traffic Commissioners. That road traffic has not been overlooked by our legislators is clearly the opinion of Mr. J. S. Nicholl, who, in his presidential address to the Institute of Transport, on October 13, stated that it is subjected to "a far greater number of legal regulations than exist in regard to any other form of industry." The making of regulations, however, is a very different thing from the taking over and operation of an industry.

Mr. Nicholl said that as the Government had taken complete control of the railways, it was fair and right that it had also assumed a measure of financial responsibility. In the case of road transport, the large number and small individual size of its constituents made such a course impossible. The immediate problem was to utilise the road-transport industry in the best national interest, preserving its sturdy individualism, which was so valuable, without undermining its financial stability. One may certainly agree that the Government cannot simply take over the road-transport industry under some type of financial guarantee. The number of businesses involved and the variation in the financial conditions which would have to be dealt with, would require such a large number of accountants that there are probably no seaside hotels left which would accommodate them.

No proposals for any scheme for the organisation of road transport were contained in Mr. Nicholl's address, but no doubt he was fully aware of the terms of the Ministry of War Transport plan, which was published a few days after the delivery of the address and of which we gave the essential details on page 333 of our last week's issue. The plan is clearly based on what is practicable, and has avoided any grandiose scheme of "complete unification." The vehicles which are to be brought under the direct control of a ministerial organisation will, presumably, be made up, in the main, from the fleets of the larger companies which already have widespread operating arrangements. In as far as its composition can be restricted to a relatively small number of owners, not only will financial arrangements be simplified, but the organisation of the whole service will be facilitated, since it would appear that those who are at present actually controlling the movements of the vehicles will continue to do so. The ease with which the railways were taken over at the outbreak of war, without interruption in their services, was due to the fact that, as industrial entities, they were not interfered with and continued to be run by the same personnel as before.

The organisation to be set up by the road-transport industry, which will allocate the traffic passed to it by the Ministry, will have as its first duty the operation of the controlled fleet, but as essential road traffic is at present by no means entirely confined to Government traffic, it may be expected to have a more instructed regard for the interests of other traffic users than it would be possible for a direct civil-service control to display. The question is not one of a greater regard for the interests of an industry; it is a matter of a detailed knowledge of the requirements of an intricate business. The third item in the Ministry's plan, covers the provision of a reserve fleet to be available for service at short notice. The organisation of such a fleet again appears to be a matter for the industry itself. There will be no lack of candidates for service in this fleet, but clearly some central organisation must exist which will have records of available vehicles, arrange that they shall be fairly distributed throughout the country, and ensure that those enrolled are in a fit condition to render them desirable units in a fleet of which much may be demanded in emergency. The only effective body for this purpose must be based on existing road-traffic organisations. A Government authority specially created for the purpose would take far too long to attain a state of effective operation.

The agenda of the Royal Commission on Transport included "transport by sea coastwise and by ferries," and it may be assumed that the complete unifiers also include overseas shipping in their sweeping contentions. For the moment, however, we may confine attention to the coastwise shipping with which the Royal Commission was concerned. Despite present dangers and difficulties, the coastwise services are playing a vital part in our transport and the recent combination of the Ministries of Transport and Shipping may be taken as evidence of the Government's opinion that closer co-ordination of road, rail and shipping services is desirable. This, however, need not be taken to imply that it contemplates unification. The only recommendation in connection with coastwise shipping which the Royal Commission was able to make was that the smaller ports used by coasting vessels should be improved.

The actual method by which coastwise shipping has been brought directly within the ambit of the war effort has been by the Government requisitioning of ships. As Sir Alfred Read, chairman of Coast Lines, Limited, pointed out at the annual meeting on October 23, that the result of this policy is that the Ministry of War Transport has been able to effect economy of tonnage by operating the vessels almost as one unit. Broadly the arrangement is the same as that entered into with the railways, the vessels continuing to be operated by their owners on behalf of the Government. There is, however, no guaranteed revenue as in the case of the railways, but the Ministry of Transport becomes responsible for the establishment charges when vessels are taken over under the Liner Requisition (Coasting and Short Sea) Scheme. Here, as in the case of the railways, the number of individual companies to be negotiated with is comparatively small and there is nothing corresponding to the hundreds of operators in the road-transport industry. These shipping and road arrangements show a wise regard for the present constitution of the industries involved and there is no indication that the Government contemplates any attempt to create some form of public authority to own and operate all inland traffic, which is what "complete unification" would appear to involve. The only wise procedure is that in the main being followed—the continued operation of transport services by those who have done so in the past.

NOTES.

GOODS TRAFFIC REORGANISATION.

THE speech which Lord Leathers, Minister of War Transport, delivered at the autumn luncheon of the British Association of Refrigeration, held in London on Monday, October 27, was the first official disclosure of a policy designed to economise land transport facilities by reducing as far as possible the distances over which individual consignments of freight are hauled, and to simplify their routing. Steps to achieve this end have been taken already by various ministries with regard to the commodities in which they are particularly interested, and much has been accomplished; but an endeavour is now to be made to apply the same principles of working to all traffic. The difficulties in the way are great, and it may be that, in the initial stages, the economies achieved will not be immediately obvious, but there is obviously room for the elimination of much cross traffic by ensuring that consumers draw their necessary supplies from the nearest available source, as is being done already to a great extent in the case of coal. This very instance, however, serves also to illustrate some of the difficulties involved, and also the possibility that the truest economy is not the most self-evident one. Users of anthracite stoves, and of types of mechanical stokers designed to burn coal of a particular grade and size, have been put to great trouble and expense in some cases because the supply of their special kind of fuel has been arbitrarily denied to them; not only so, but the material and labour absorbed in converting plant to use other fuels must have represented, in many instances, a drain upon the national reserves for which the actual saving in coal haulage is only a partial compensation. It is difficult enough to strike a true balance between the pros and cons in a single instance such as this; and if the Ministry of War Transport fails at first to do so for the whole inland traffic of the country, the shortcoming need cause no surprise. If the aim can be achieved for the more bulky commodities as a start, the benefit should be appreciable; but when the policy comes to be extended to traffic of a more general character, there will be an urgent need to watch that the machinery of re-organisation does not absorb more effort than the result releases for other purposes. In any case, the new policy is not likely to benefit the railways from the financial standpoint, for short hauls have never been an economical or profitable feature in railway operation.

INSTITUTION OF ELECTRICAL ENGINEERS.

Sir Noel Ashbridge, President of the Institution of Electrical Engineers, delivered his inaugural address at a meeting held in the Institution's lecture hall on Thursday, October 23. Before the address a number of premiums awarded by the Council for papers read during the previous session were handed to the recipients. We mentioned these awards on May 23, 1941. As Sir Noel is Controller of the Engineering Division of the British Broadcasting Corporation, his address was naturally concerned mainly with broadcasting, in which he has specialised for many years. Obviously he was unable to mention the many developments made since September, 1939, but he referred to the possibility that the part which radio engineering has played in the present war would be described before the Institution at some future date. When that time came, he said, there would be no lack of material of intense, or even romantic, interest. A considerable portion of the address was devoted to the development of broadcasting in this country, on which our readers have been kept reasonably well informed, largely owing to the courtesy of the Engineering Division of the Corporation under Sir Noel's control. He mentioned, in this section of the address, that just before the outbreak of war nearly 90 per cent. of the British public could obtain good reception of two programmes, and over 98 per cent. of one programme. The small remaining section of the community who were unable to get entirely satisfactory reception of even one programme included those persons living in the remoter parts of Cornwall, the north-west and west of Scotland, and the extreme west of Northern Ireland. While speaking of future developments in transmission, Sir Noel mentioned the subject of "frequency modulation," which he said had made considerable progress in the United States during the past two years. This method of transmission would have been investigated experimentally in this country before now if the war had not made work of this kind impracticable. Part of the address was devoted to the position and prospects of television, and it was mentioned under this heading that although a regular service of television had been available for about three years before the war, the number of persons owning television receivers was probably less than 30,000 although there were some 2½ million households within the service area of the one transmitter then operating in the London area. Causes contributing to the comparatively slow response on the part of the public were the high prices of receivers and the somewhat restricted area in which the service could be received. The technical side of television was, however, of great interest to radio engineers and it was hoped that the many remaining problems would be solved on the right lines in the future. Before the meeting the Council Luncheon was given at the Savoy Hotel, the President occupying the chair.

COMMITTEE ON BUILDING IN COUNTRY AREAS.

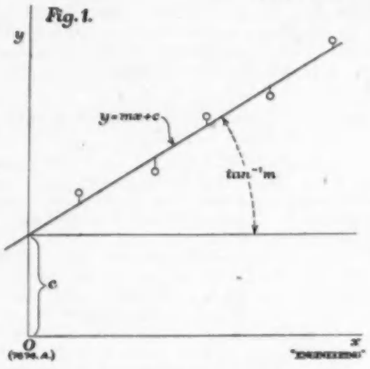
Some time ago the Government announced its intention to set up, at a future date, a Central Planning Authority to direct physical reconstruction in town and country at the end of the war. Evidently a great deal of thought will have to be devoted to the establishment of the guiding principles upon which this Authority should work, and, among the many problems that will arise will be that of the development of the countryside along various lines. New problems have arisen since the publication of the report of the Royal Commission on the Distribution of Industrial Population, which advocated the decentralisation of industry from congested urban areas. Decentralisation into the countryside is already taking place on a considerable scale in connection with industries essential to the prosecution of the war, and it will have to be decided what use should be made of these war-time industrial establishments in the post-war period. In addition, there will be problems of housing arising out of the re-planning of damaged or congested urban areas. Any general policy of industrial or residential decentralisation would have far-reaching effects on the countryside and on agriculture and if the decentralisation, or dispersal, of industry and the creation of new residential centres in rural areas is to be effected, even on a limited scale, it will be necessary to consider what are the industries which are suitable for location in small towns, villages, and country districts—suitable not only in that they will have a good chance of economic operation, but also from the point of view of their effect on agriculture. Obviously, new industries which enter into competition with agriculture in the labour market may have a seriously unbalancing effect on the area in which they are situated. Consequently, consideration may have to be given to decide whether any restrictions, and if so, what type of restrictions, should be put on the establishment of industries in country districts. Moreover, the fact that once land has been taken over for building purposes the position is irremediable in so far as agriculture is concerned will have to be considered. Hence control will be necessary to ensure that buildings will not prevent the productive use of good agricultural land or that they will not destroy natural amenities. To consider these matters and to make recommendations, Lord Reith, after consultation with the Minister of Agriculture, has appointed a Committee on Building and Other Constructional Development in Country Areas. The terms of reference of this Committee are "To consider the conditions which should govern building . . in country areas consistently with the maintenance of agriculture, and, in particular, the factors affecting the location of industry, having regard to economic operation, part-time and seasonal employment, the well-being of rural communities and the preservation of rural amenities." The chairman of the Committee is Lord Justice Scott and the members comprise Lord Addison, Lord Radnor, Lady Denman, Mr. R. Cobb, Mr. H. S. Cooper, Mr. S. R. Dennison, Mrs. Lionel Hichens, Mr. A. E. Monks, Mr. L. Ramsbottom, Mr. R. H. Roberts, Mr. P. Robinson, Dr. L. Dudley Stamp, and Mr. R. A. Ward. The joint secretaries are Messrs. Thomas Sharp and B. C. Engholm, Lambeth Bridge House, London, S.E.1.

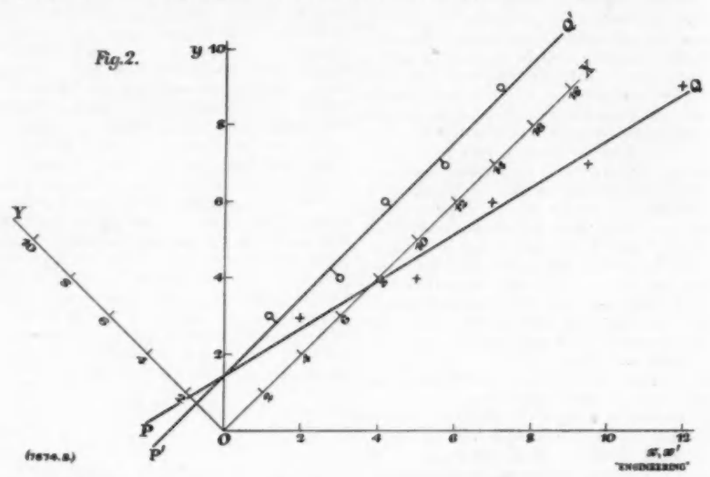
NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

The annual report of the Council of the North-East Coast Institution of Engineers and Shipbuilders, which was presented at the annual general meeting held in Newcastle-on-Tyne on October 17, showed that the membership stood at 1,270. The active co-operation of the members of all grades enabled the Institution to conduct successfully a second war-time session, during which twelve meetings were held. A similar number of meetings was held by the Student Section. The James Medal for 1941 was awarded to Mr. W. T. Bottomley for his paper on "The Economics of the Design of Condensing Plant and Cooling-Water Systems as applicable to Power Stations." This paper was reproduced in vol. 151 of ENGINEERING, pages 417, *et seq.* During the session, the Council completed the scheme of membership affiliation with the Society of Naval Architects and Marine Engineers, New York; under this scheme, members of either body can be admitted to the other without the payment of entrance fee, and without the formality of obtaining proposing and supporting signatures, the place of which is taken by a certificate from the secretary. The Inventions Committee, the appointment of which was noted in our issue of March 28, 1941, page 253, was reported to have had various proposals under consideration. As in the previous session, the committees of the Tees-side and Sunderland branches of the institution deemed it inexpedient to hold meetings. The Institution scholarship for 1941 was awarded to Mr. Harold Greenhow, an engineering apprentice of Hartlepool, who is to study at King's College, Newcastle-on-Tyne. A bursary of 50*l.* was awarded to Mr. I. H. Axbey, an apprentice ship draughtsman, who will also study at King's College; and a prize of 5*l.* to Mr. W. G. Geddes, a student apprentice. The Weighton Medal for the session was awarded to Mr. Johannes K. Lunde, on the recommendation of King's College, upon his results in the final examination for the pass degree of B.Sc. in Applied Science. The annual examination of the measured-mile posts at Whitley Bay (for the custody of which the Institution is responsible) showed that the posts had suffered considerable deterioration in parts of the metal structure; it was stated that the extent of renovation and replacement necessary was receiving the Council's attention, in consultation with specialist advisers. The membership of 1,270, previously mentioned, included two new Fellows, this distinction having been conferred upon Mr. W. A. Woodeson (President) and Mr. Norman M. Hunter. We observe among the names of recently deceased members that of Mr. W. G. Green, associate-member, who was one of the group of young engineers who, in co-operation with Mr. W. G. Spence, took the initial action which led to the foundation of the Institution in 1884.

WIND-ACTUATED ROTARY STRAINER.—An interesting application of wind power is described in the current issue of the *Glenfield Gazette*, the house journal of Messrs. Glenfield and Kennedy, Limited, Kilmarnock. A water supply in Ayrshire is taken from a reservoir through a Peebles automatic rotary strainer, the drum of which was originally driven by a small water motor through double-reduction gearing. Experience showed that the driving water was not always available, and the water motor has, therefore, been supplemented by a wind motor consisting of a small windmill constructed by adding radial vanes to a motor-cycle wheel. Transmission is by means of bevel wheels and a chain, and a free-wheel device is incorporated. This device permits the water motor to function without rotating the wind motor, but, when the water power fails the wind wheel automatically takes up the drive. It is stated that the wind wheel turns on some 300 days of the year and when a strong wind is blowing the increased debris finding its way into the strainer is readily dealt with by the additional power supplied from the wind motor.

THE CONSTANTS OF STRAIGHT-LINE LAWS.





THE CONSTANTS OF STRAIGHT-LINE LAWS.

By G. F. Freeman, M.Sc.(Eng.), A.M.I.E.E., A.M.I.Mech.E.

In the interpretation of experimental data it often happens that plotted points are seen to be well represented by a straight line; frequently there is some theoretical basis in support of such a relation. The practical problem is to find the line which most probably correlates the data, since minor deviations are inevitable. In many cases the eye may be a sufficient guide, and if the points are fairly evenly distributed it is a good and common practice to draw a line which leaves the same number of points on each side. For closer analysis, however, the method of least squares is available.

In its usual form, this enables a line $y = m\,x + c$, Fig. 1, to be found, such that the sum of the squares of the ordinate deviations shall be a minimum. It is not always realised that this also makes the sums of the positive and negative deviations equal, but a little reflection makes it clear that this must be so; the familiar proposition that the moment of inertia of a system of bodies is least when taken about their centre of gravity is another instance of the same principle. The application of the method, which is quite straightforward, is ordinarily conducted by tabulating the values of the n points (x_1, y_1) to (x_n, y_n) and working out ancillary products and squares. On summation, the slope m and axial intercept c are given by

$$m = \frac{n\,\Sigma_1^n (x_1\,y_1) - \Sigma_1^n x_1\,\Sigma_1^n y_1}{n\,\Sigma_1^n (x_1^2) - (\Sigma_1^n x_1)^2} \quad . \quad (1)$$

and

$$c = \frac{\Sigma_1^n y_1 - m\,\Sigma_1^n x_1}{n} \quad . \quad . \quad . \quad (2)$$

The proofs are simple and will not be given here.

The implied assumptions are that all points carry equal weight and that, x being the independent variable, errors are more likely to occur in y; hence ordinate and not abscissa deviations are considered. Occasions frequently arise, however where for one reason or another more weight attaches to some of the points than to others. Assigning a loading factor w_r to the point (x_r, y_r), we now have

$$m = \frac{\Sigma_1^n w_1\,\Sigma_1^n (w_1\,x_1\,y_1) - \Sigma_1^n (w_1\,x_1)\,\Sigma_1^n (w_1\,y_1)}{\Sigma_1^n w_1\,\Sigma_1^n (w_1\,x_1^2) - \{\Sigma_1^n (w_1\,x_1)\}^2} \quad (3)$$

and

$$c = \frac{\Sigma_1^n (w_1\,y_1) - m\,\Sigma_1^n (w_1\,x_1)}{\Sigma_1^n w_1} \quad . \quad . \quad . \quad (4)$$

The weighting may be systematic or casual. For example, if equal *percentage* deviations are probable, the weighting factor should be $w_r = \frac{1}{y_r}$. Again, if the original data should obey a law $y^q = a + b\,x$, q being known, and the deviations in y are equally probable at all points, when $u = y^q$ is plotted against x to determine a and b, a deviation of $\Delta\,y$ in y will correspond to a deviation of approximately $(q\,y^{q-1}\,\Delta\,y)$ in u; an appropriate weighting factor will therefore be $w_r = \frac{1}{y_r^{q-1}}$. Or it may be arbitrarily decided that certain points obtained by one method are probably inferior in accuracy to others obtained by a second method by, say, 50 per cent.; in that case, $w = 1$ for the first series and $w = 2$ for the second.

Where deviations are probable in both x and y, and there is little to choose between them, m and c may be found as above, and a further pair of values computed by interchanging x and y in the formulæ (corresponding to deviation in x only). The best representative values to take are then not far from the arithmetic means of these two sets. That this is so may be demonstrated by approaching the problem in another way. In Fig. 2, which illustrates the process, values of x and y are shown by crosses, corresponding to the first two columns of Table I.

Table I.

x.	y.	$x' = 0{\cdot}6\,x$.	$X = y + x'$.	$Y = y - x'$.	X Y.	X^2.
2	3	1·2	4·2	1·8	7·56	17·64
5	4	3·0	7·0	1·0	7·00	49·00
7	6	4·2	10·2	1·8	18·36	104·04
9·5	7	5·7	12·7	1·3	16·51	161·29
12	9	7·2	16·2	1·8	29·16	262·44
		Σ	50·3	7·7	78·59	594·41
		M = 0·01275		C = 1·412		

By inspection, m is seen to be about 0·6, and the abscissæ are now reduced in this proportion (points shown by small circles, figures in third column). By a simple addition and subtraction the next two columns relate these points to axes O X and O Y inclined at 45 deg. to the original axes (there is also a change of scale by $\sqrt{2}$, which is of no consequence), the axis O X being practically parallel to the run of the points, so that application of (1) and (2), following the summations of the last four columns, gives a line P′ Q′ to which the deviations in Y are virtually perpendicular, the slope M approximating to zero. The corresponding constants referred to O x' and O y are given by

$$m' = 1 + 2\,(\mathrm{M} + \mathrm{M}^2 + \ . \ . \ .) \quad . \quad (5)$$

and

$$c = \mathrm{C}\,(1 + \mathrm{M} + \mathrm{M}^2 + \ . \ . \ .) \quad . \quad (6)$$

The final line P Q referred to the original axes has the same c but only $0{\cdot}6\,m'$ as slope (0·6 being the original estimate of the approximate slope).

The work has been arranged in this way to cut down the arithmetic as much as possible. Trigonometrical forms can be used to effect the change of constants, but the short series given, which converge very rapidly, are thought to be more convenient. It will be clear that the method can be adapted by weighting to suit diverse conditions, and in a modification account may be taken of say a two to one probability of deviation in y as compared with x. In such a case, however, it will usually be sufficient to weight the averages from plain "y" and "x" determinations ((*a*) and (*b*) in Table II).

Constants obtained by these various methods from the same data are given in Table II, the last line indicating the effect of a "percentage" weighting. It will be clear that method (*c*) is so close to

Table II.

Method.	m.	c.
(*a*) Least squares in y	0·608	1·483
(*b*) Least squares in x	0·623	1·377
(*c*) Average of (*a*) and (*b*)	0·6155	1·430
(*d*) "Tilting axis" method	0·6158	1·430
(*e*) As (*a*), but weighted $w_r = \frac{1}{y_r}$	0·591	1·582

the alternative (*d*) that it can be used with confidence where desired; as far as arithmetic goes there is not much in it, but (*c*) may be thought more straightforward.

THE INSTITUTION OF MECHANICAL ENGINEERS.

A general meeting of the Institution of Mechanical Engineers was held at Storey's Gate, St. James's Park, London, S.W.1, on Friday, October 24, the chair being occupied by the President, Mr. W. A. Stanier.

Appointment of Secretary.

The first item on the agenda of the meeting was the consideration of the appointment of a new secretary. The President said that, as Mr. J. E. Montgomrey would attain the pre-arranged age for retirement next year, the Council was faced with the task of choosing a successor. It had come to their knowledge that Dr. H. L. Guy was retiring from engineering industry and since recent practical experience such as he possessed was a valuable asset for the post, the Council now made a recommendation, in accordance with By-law 50, that Dr. H. L. Guy, D.Sc., Wh.Ex., F.R.S., be appointed Secretary to the Institution as from March, 1942, in place of Mr. Montgomrey. This recommendation, being seconded by Brig.-General Magnus Mowat, C.B.E., T.D., F.R.S.E., was then put to the meeting and unanimously agreed to.

Changes in Council.

The minutes of the previous meeting having been read, approved and signed, it was announced that Mr. R. E. L. Maunsell, C.B.E., M.A. (Hon. Life Member), had resigned his position as a member of Council. Mr. Maunsell had been associated with the Council since 1923, including a term of seven years as Vice-President. It was also announced that Professor Dempster Smith, M.B.E., M.Sc.Tech. (member of Council), had been elected on July 18 an Honorary Life Member of the Institution. Professor Dempster Smith was elected an associate member in 1907, transferred to membership in 1913, and has

been a member of Council since 1932. He has been prominently associated with many aspects of the Institution's work, notably in research on cutting tools.

PRESIDENTIAL ADDRESS.

After the secretary had announced the election of new members of various grades, Mr. Stanier delivered his Presidential Address, which was entitled "The Position of the Locomotive in Mechanical Engineering." We commence to reprint the address in abridged form, on page 357. The meeting hall was full to capacity and the address created great interest, two cinematograph films, made by the Research Department of the London Midland and Scottish Railway, attracting particular attention. One of these illustrated the oscillation, during running, of new and worn railway-coach wheels with differently-coned treads and with a cylindrical tread; and the other, the hammer-blow effect of locomotive driving wheels on the track, with different proportions of the reciprocating parts balanced. In one case, the driving wheels lifted some 2¼ in. from the track at full speed. At the conclusion of the address, a vote of thanks was proposed by Mr. Asa Binns, past-president, who said that Mr. Stanier's extensive subject had been admirably handled and he regretted that Lord Stamp had not survived to hear the address. He was glad that Mr. Stanier had included a section on the training of the engineer. This, he knew, was a subject the President had much at heart, and he fully agreed on the absolute necessity of including practical work in such training.

The vote was seconded by Mr. O. V. S. Bulleid, member of Council and chief mechanical engineer of the Southern Railway, who remarked that the address was characteristic of the President in that it was thoroughly practical and informative. Mr. Stanier, he said, apart from his professional abilities, enjoyed the sincere esteem of railway engineers generally. The vote was accorded with acclamation.

THE STANDARDISATION OF TESTING METHODS FOR ALUMINIUM ALLOYS.

A STRONG plea for the standardisation of the methods employed in the fatigue testing of aluminium alloys and in the determination of their mechanical strength at elevated temperatures, has recently been made in a communication received from Mr. H. F. James, of the Northern Aluminium Company, Limited. In assessing the merits of various materials for a particular application, Mr. James states, designers usually have available a wealth of quantitative data regarding the mechanical properties of each material. In cases involving only simple designs, or merely entailing modification of a design on which long experience has previously been gained, the data available are usually sufficient to enable a sound choice of materials to be made. By applying a reasonable factor of safety, it can be ensured that, under conditions of static loading, the limiting stress which the final product will be required to withstand will lie well within the mechanical properties of the material. Into the general testing of metals and alloys, namely, the determination of the ultimate tensile strength, proof stress, elasticity and hardness values, a considerable measure of standardisation has been introduced, particularly in the case of materials which conform to official specifications. The data obtained from such tests, therefore, enable accurate comparisons of materials to be made.

Unfortunately, Mr. James continues, this does not apply to the fatigue testing of aluminium alloys, or to the measurement of their strength at high temperatures, although it is in these two particular directions that the most accurate information is necessary. It is widely known that any metal or alloy will fail under a stress considerably lower than that represented by its ultimate stress value if the load be applied and removed a large number of times. If failure under such alternating stresses is to be guarded against, therefore, accurate information must be available regarding: (*a*) the number of stress cycles necessary for a given stress to cause failure; and (*b*) the limiting stress range, if any, for the material—below which failure will never occur no matter what the duration of the test may be. Several types of machines are used for carrying out fatigue tests, the most common being that known as the rotating-beam machine. The types of tests most frequently applied are those involving complete reversals of tension-compression stresses, but as will be readily appreciated, many combinations of stressing and straining actions are possible. In view of the complexity of the stresses which may actually be encountered, it is desirable that the conditions of the test should be arranged to simulate, as closely as possible, those to which the actual component will be subjected in service. It is, however, universally admitted that in the majority of fatigue tests the conditions of testing are far from conforming to this requirement. For example, tests involving tension-compression stress reversals are only directly applicable to cases in which the material under test is to be used for components which will be subjected to such a type of stressing action. This is rarely found to occur in practice, although Hartmann* quotes a railway-coach axle, which rotates in its journal so that the extreme fibres pass alternately through tension and compression, as an example where such a test may justifiably be employed. In most cases, the stresses encountered in actual operation are so complex as to render it almost impossible to reproduce them accurately in a test, this naturally reducing the value of the test result. Moreover, the issue is further complicated by the fact that the result of the test is greatly influenced by the shape, size and surface finish of the test piece and the physical condition of the material. Thus, it is not surprising to find that a particular material, such, for example, as heat-treated Duralumin, when subjected to fatigue tests employing different stressing and straining actions, will give consistent results under each set of conditions but will show appreciable variation of results from one set of conditions to another.

In some cases the possibilities of error have been minimised by resorting to full-scale testing, that carried out on certain members of the Sydney Harbour Bridge furnishing a classic example. For obvious reasons, however, it is impossible to adopt this practice in every case and thus the need for reliable small-scale test data remains. A vast quantity of work has been carried out to meet this need, but in attempting to overcome the inherent difficulty of the problem, types and conditions of testing have been so varied that the present position, from the designer's point of view, is extremely confusing. It is, therefore, becoming felt to an increasing extent that methods and equipment for fatigue testing should be subjected to a considerable measure of standardisation, so that test results will enable at least reasonably accurate comparisons of different materials to be made. The results of standardised tests would provide designers with accurate knowledge of the behaviour of materials under standard conditions regarding the shape, size and surface finish of the test piece, and the physical condition and type of stressing and straining action, and they should at least provide a foundation on which to base work intended for any particular application. Research on the subject could be directed into well-specified channels and the literature would then be of considerable help in design.

The testing of a material at elevated temperatures does not involve the intricacy and difficulty inherent in fatigue testing. The problem, in fact, is closely comparable with that encountered in the testing of aircraft performance. In this latter case, as is well known, figures obtained in actual tests are not themselves officially accepted, they are merely used to compute the performance in an atmosphere standardised with respect to all variables for each altitude. Comparisons of the performances of different aircraft are, therefore, highly accurate. Similarly, if comparisons of the mechanical strength of aluminium alloys at elevated temperatures are to be accurate, the test data used should be carried out in such a manner that all variables in testing procedure and conditions are under strict control. The simplest way to ensure this is to standardise the tests with regard to the size, shape and finish of the test pieces, the temperatures of testing, the time of soaking, and the rate of straining.

It is also important that the test conditions should approximate as closely as possible to those encountered in service. Thus, in the testing of piston materials, it is particularly important that the soaking be carried out for an adequate period. If the soaking period is too short, considerable temperature differences will exist between the surface and the centre of the test piece and the result obtained will be in no way indicative of the strength of the piston after some hours of running in an internal-combustion engine. Mr. James states, in conclusion, that lack of such standardisation, and the failure to state the conditions of testing when publishing the results of tests, has led to considerable confusion and to the making of valueless comparisons of the behaviour of the various light alloys available for use at elevated temperatures. Until such time as the necessary measure of standardisation is introduced, designers when making a choice of material, should take close account of the conditions of testing, particularly with regard to the time of soaking and the rate of straining.

* See E. C. Hartmann, "Fatigue Test Results," *Product Engineering*, New York, February, 1941.

ENTRY AND PROMOTION IN THE ROYAL NAVY.

As some confusion may arise in the minds of the general public regarding the exact extent of the new methods of entry into the Royal Navy and the avenues of promotion to commissioned rank that are now available, it is convenient to have these clearly stated, as has been done in a memorandum recently issued from the Ministry of Information and based upon the relevant Admiralty Fleet Orders. The first of these new modes of entry is the system of scholarships established at Dartmouth for the benefit of secondary-school boys whose parents could not otherwise afford the expense of a Dartmouth training. These scholarships are awarded on the results of a competitive examination. Candidates must be medically fit, and must be adjudged suitable in other respects for naval service by an Interview Board. There are 30 scholarships a year (ten in each term) for boys from grant-aided secondary schools, and an equal number may be awarded also in each term to boys from other schools. All the cadets are on exactly the same footing with regard to pay, pocket money, etc. The parents contribute according to their means; but, if they cannot afford to contribute at all towards the cost of a boy's fees, upkeep or uniform, or to keep him during the holidays, provision is made in the scheme to cover such contingencies also. One scholarship is available for the son of a naval rating.

Another of the new forms of entry is the "Y" Scheme, which concerns youths of 17 or over, who have not yet been called up for service. This group can volunteer for the Navy (including the Fleet Air Arm) and as soon as they are wanted—which will not be before they are 18—they will be called up. Volunteers are only eligible if they are medically Grade I, and must have either a School Certificate or a satisfactory explanation from the headmaster of the school to account for the lack of it. A volunteer can go straight into the Navy from any school, if he possesses these qualifications, or can go on from school to a university after volunteering. Those who are at universities and who are subject to the National Services (Armed Forces) Acts, will be called up in the ordinary way unless their University Joint Recruiting Board testifies that it is in the national interest that they should remain; this will apply mainly to men who are specialising in certain kinds of work. While waiting to start their naval career, however, they must do a certain amount of voluntary training; this is an important preliminary to their naval career, and one to which great value is attached. They will not receive any uniform until they begin their proper naval training, but they will be saved the expense of travelling to and from the naval centre. The "Y" Scheme, therefore, opens the door to a naval career well in advance of actual entry. Those who have registered already for compulsory service are not eligible for the "Y" Scheme except that, until they reach the age of 28, they may apply to become pilots or observers in the Fleet Air Arm.

The lower-deck rating who aspires to a commission does not himself apply for it in the first instance; it is a duty of his commanding officer to pick out suitable men and to commence a "White Paper" for him—this being a docket in which all relevant information about him is filed. After he has spent three months at sea, and provided that his commanding officer still considers him suitable, he is sent before a preliminary Selection Board. If he is passed by this Board, and has shown himself to possess initiative and capacity for leadership, he will be interviewed by the Admiralty Selection Board, and, if he satisfies them, will be sent as a cadet rating to H.M.S. King Alfred, the Navy's Graduation School for "hostilities only" officers.

A cadet rating spends about ten weeks in the King Alfred establishment, where selection is based entirely on merit and pays relatively little attention to other qualifications. The course includes seamanship, signals, navigation and pilotage, and lectures on leadership as well as instruction on the welfare and advancement of ratings. After completing the course and the written tests, the cadet rating appears before the Passing-Out Board for an examination which is entirely oral. If he fails to reach or to pass this Board, he is drafted to sea again; but his commanding officer may start a new "White Paper" for him if he justifies it, or the Admiralty Selection Board may recommend him for a higher rating if he fails to qualify for a commission. When he passes out, he becomes a Probationary Temporary Sub-Lieutenant, R.N.V.R., if over 21; or a Probationary Temporary Acting Sub-Lieutenant, if between 20 and 21. If he is under 20 years of age, he is a Probationary Temporary Midshipman, R.N.V.R., and will be sent for more training, probably in small craft, or, if he wishes to enter the Fleet Air Arm, to H.M.S. St. Vincent, after another, and somewhat severe, medical test. It is emphasised that there is rarely any good reason for a rating, who has been recommended for a commission, to hold back on the score of expense.

CANADA'S WAR EFFORT.

A striking summary of the extent of Canada's war effort is contained in the October *Monthly Letter* of the Royal Bank of Canada, by way of a reply to certain misrepresentations on the subject which, it is asserted, have been made by isolationist interests in the United States. Official statements are quoted to show that more than 490,000 Canadian sailors, soldiers and airmen have been enrolled, of whom 100,000 soldiers and airmen are now serving outside the Dominion. On the basis of comparative populations, it is claimed, this is equivalent to the enlistment of 5,500,000 men by the United States and the dispatch of 1,100,000 overseas. Two years ago, Canada's navy comprised only 15 vessels, and a total personnel of 1,700. To-day, it includes more than 25,000 men and some 250 vessels—destroyers, armed merchant cruisers, corvettes, minesweepers, patrol ships, and anti-submarine craft.

Since September, 1939, the Canadian Army has grown from 4,500 men to a force of 230,000, all volunteers and enlisted for service anywhere; many are on duty in the West Indies and at Gibraltar, in addition to those in England and Newfoundland. The non-permanent Militia has expanded from 45,000 to 170,000 men, available for duty in Canada as a reserve army, should the need arise. The Royal Canadian Air Force began with 4,000 men and now has 80,000, with the British Commonwealth Air Training Scheme operating 120 separate establishments in Canada. Eighty per cent. of the students at these schools are Canadians. The other 20 per cent. come from all parts of the Empire, and some are from the United States. The total cost is estimated to be 824 million dollars for the first three years, of which sum Canada is contributing 531 million dollars. So far there is no conscription in Canada, but it has not been found necessary, as voluntary enlistments have been sufficient for all requirements; indeed, the Air Force and the Navy have had a surplus of applicants at all times.

On the financial side, Canadians have provided Great Britain with about three-quarters of the Canadian dollars needed to purchase war supplies in the Dominion, and will continue to finance the greater part of Britain's expenditure there. In addition to the value of British goods sent to Canada, Great Britain has already needed 1,000 million dollars to cover these purchases. About a quarter of this sum has been paid in gold; but all of this gold, "and much more," states the *Monthly Letter*, has been transferred to the United States to meet British orders, and there have been no gold shipments from Great Britain to Canada since December, 1940. The remaining 750 million dollars Canada has supplied, although, in the process of doing so, it has been necessary to sell the whole of the gold reserves, and to realise substantial Canadian investments in the United States.

"On September 15," continues the *Letter*, "it was officially announced that actual deliveries by the United States up to August 31 under the Lease-Lend Act had a value of 325 million dollars; expenditures for articles or services not yet completed had an additional value of 162 million dollars, making 487 million dollars in all. It is perfectly clear from official statements that Canadian sales to Great Britain on open account, without, we believe, any more definite understanding regarding repayment than under Lease-Lend operations, have certainly greatly exceeded total deliveries to date from the United States."

The Control of Drop Forgings.—No drop forgings produced by hammers of 20 cwt. and over may be manufactured after November 1 unless they are covered by approved schedules in accordance with the instructions of the Drop Forgings Sub Control. Firms placing orders for drop forgings under Board of Trade steel authorisation must submit schedules of their orders, in triplicate, on form BT/DF 1, to the Industrial Supplies Department, Drop Forgings Section, Board of Trade, Millbank, London, S.W.1, who will forward approved schedules to the drop forgers named. Schedules for drop-forging orders placed under the authorisations of other departments, however, should not be forwarded to the Board of Trade, but to the department issuing the authorisation.

Dross Formation in Hot-Dip Galvanising.—In a paper presented before the American Hot-Dip Galvanisers' Association, and reprinted in recent issues of *Steel*, Messrs. R. J. Kepfer and L. D. Eubank report on an investigation of the difference in the amount of dross produced in galvanising low-carbon steel sheet pre-dipped in a zinc-ammonium chloride solution, as compared with similar material pre-dipped in dilute hydrochloric acid. It was found that, on the average, the amount of iron dissolved in the galvanising bath was about 60 per cent. greater when using the hydrochloric acid dip than when using the zinc-ammonium chloride dip. In other words, the proportion of dross formed after pre-dipping in hydrochloric acid was appreciably greater.

LABOUR NOTES.

At October 1, the official cost of living index figure was 99 points above the level of July, 1914, showing no change compared with September 1. For food alone, the index figure at October 1 was 65 points above the level of July, 1914, compared with 66 points at September 1. The decline was due to a decrease in the price of fish and potatoes. Among items other than food, the only important change was a slight rise in the average level of prices of clothing and clothing materials, partly due to the effects of the Purchase Tax. Since that tax came into operation in October, 1940, the resulting increases in prices have raised the cost of living index figure by approximately six points.

In the House of Commons on Thursday last week, Mr. Lyons, the Unionist Member for Leicester East, asked the Minister of Labour and National Service whether he had yet taken, or if he proposed to take, any power of compulsion for the recruitment of women for any form of national service. Replying, Mr. Bevin said that his powers under the Defence Regulations with regard to directing persons to employment applied equally to women and to men. Mr. Lyons asked if it was not a fact that no such powers had ever yet been taken in connection with the recruitment of women for any form of national service and that Mr. Bevin had relied on achievements, speeches and platform oratory for results. Mr. Bevin said that on the contrary, women had been directed to work and had been registered. He was not relying exclusively on appeals, but this was a free country and he intended to use the freedom to the best of his ability. Women were registering, the Minister added, extremely well.

In the course of the man-power and women-power debate in the House of Lords on Wednesday last week, Lord Moyne said that the registration of women had shown an unexpectedly high proportion already fully employed; 90 per cent. of single women and widows in the 20-25 class were in full-time paid employment. The number of married women in that age group who were in full-time employment was rather smaller, but allowing for household occupations 97 per cent. of them were fully employed, though not paid. What was needed was a continually growing number.

Continuing, Lord Moyne said that some of the prejudices against the use of women would have to be got rid of. It had to be remembered that all men were not fit, nor all women frail. At present, one of the biggest problems to be tackled was that of getting another 140,000 women for the A.T.S. Pledges had been given that the A.T.S. would be a women's service under women, but, as they were given new kinds of employment it was inevitable that in some matters its members should come under the operational control and instruction of men. For instance, he pointed out, women were not yet trained instructors in the use of the kine-theodolite and predictors or in such highly technical work as signalling.

Speaking in the House of Lords on Thursday last week, Lord Beaverbrook said that when the workers had finished their jobs and given the country a stock of munitions, guns, aircraft and tanks, they must be prepared to leave their benches and factories and take up the weapons they had made in order to defend these islands. "If," he declared, "when the attack comes on Britain—as it surely will—you may rest assured that the whole population will be involved, just as the whole population is involved in the defence of Moscow."

An interim scheme for the training and re-settlement in industry of persons disabled while on war service or in civil life is being prepared by the Minister of Labour and National Service. It will cover all disablement, however caused—by wounds, industrial or other accidents, or disease—and it will not exclude sufferers from road accidents. The facilities provided are to be available to all persons, over 16 years of age, who are unfitted by disablement from resuming their normal occupations as well as to those who are handicapped by disablement in their efforts to obtain satisfactory employment. During the hostilities, it will be necessary to concentrate the training for occupations vital to the war effort, but it is hoped that the experience gained in the interim period will be useful in developing the scheme later.

The Minister of Health is fostering schemes of hospital treatment and rehabilitation of disabled persons and the plan of the Minister of Labour and National Service is to work in with these arrangements by getting into touch with disabled persons while they are still in hospital. From the patients themselves, and from the doctors and surgeons, individual requirements of employment will be ascertained. By making contact with a patient before the completion of his hospital treatment, the Ministry, it is hoped, will be able so much earlier to interest itself in his future and the return to employment be made easier and quicker. The present admittedly limited experience suggests, it is stated, that a large proportion of the disabled will be able to resume their former or another occupation without training.

In March last, the Canadian Minister of Labour sent a letter to employers and also to secretaries of trade unions in which he stated that many claims had been made that workers of foreign name or origin had been finding it difficult to secure or to maintain employment. While admitting the need to exercise proper vigilance, he emphasised that "unjust discrimination should be avoided against those who, although not born in the country have been accepted as citizens or residents and as such have the right to earn their living." "For the final outcome of the war," the Minister added, "we require the help of the various nationalities represented in our population, regardless of creed or racial origin; we cannot hope to build up a truly national spirit if we have not the support of those who have given Canada the allegiance they formerly owed to the country of their birth."

Older Canadian workers who are highly skilled and experienced have been re-employed and employer specifications regarding age have been radically modified in the higher skilled categories, but low-skilled older workers continue to find it difficult to obtain employment despite the shrinkage in the available reserve of unemployed labour power. "It is unfortunate," the Minister went on to say in his letter, "that a great many people between the ages of forty and fifty who found themselves unemployed during the period of depression are finding the greatest difficulty in getting back into employment. I regret that this is the situation. Probably, the time will come when it will be necessary to urge, much more strongly than we have been able to do up till the present, that many of these persons be employed in industry. It may be that younger people could do the work to better advantage, but there may be some other work to be done by younger people that older people cannot do, and in such instances it might be necessary to urge the employment of many of those who were on these lists made up under the voluntary effort."

Under an Order of the General-Government in German-occupied Poland, the amount of unemployment assistance varied according to the applicants' wages when in work and his "place of residence." A third criterion has since been added, namely, nationality, and under the new arrangement non-Germans are penalised. The *Review* of the International Labour Office states that the rates of allowance are 25 per cent. higher for workers belonging to the German nation (Deutsche Volkszugehörige) than for other workers. The dependant's allowance in the case of non-Germans is at the rate of 4.00 zlotys for one dependant and 2.50 zlotys for each additional dependant up to and including the fifth. The corresponding rates for Germans are 5.00 zlotys and 3.10 zlotys, respectively.

An investigation carried out by the Industrial Relations Division of the United States Bureau of Labour Statistics shows that nearly one-third of the employees engaged in the manufacture of aircraft and aircraft parts are covered by collective agreements. Under all the agreements on file with the Bureau of Labour Statistics, time and a half is paid for work in excess of eight hours a day and 40 hours a week. Most of the workers are paid time and a half for work on Saturday unless such work is part of the regular schedule, and more than two-fifths receive double time for work on Sunday if such work is not included in their regular schedule. Nearly three-fourths are paid double time for work on recognised holidays.

In the basic iron and steel industry more than two-thirds of the employees are covered by collective agreements, whereas only about half of the fabricating employees are under agreement. Most of the agreements call for the eight-hour day and the 40-hour week, with the payment of time and a half for all overtime. Although only a few agreements require the payment of double time for all overtime, a considerable number call for double time after two or four hours overtime in any one day. Penalty payments for Saturday, Sunday and holiday work are common in the fabricating branch of the industry, but rare in the basic iron and steel branch—in which there is, of course, a good deal of continuous operation.

BRITISH LOCOMOTIVE ENGINEERING.

FIG. 1.

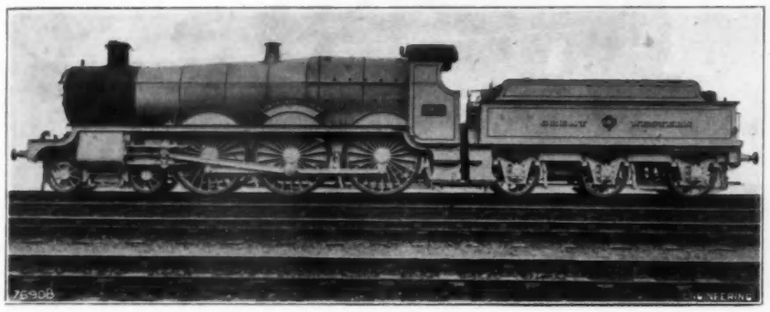


FIG. 2.

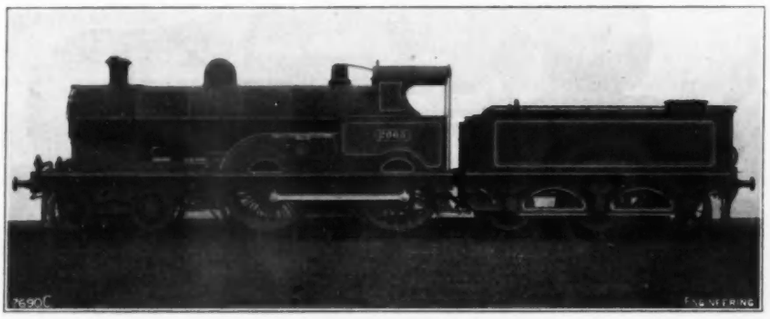


FIG. 3.

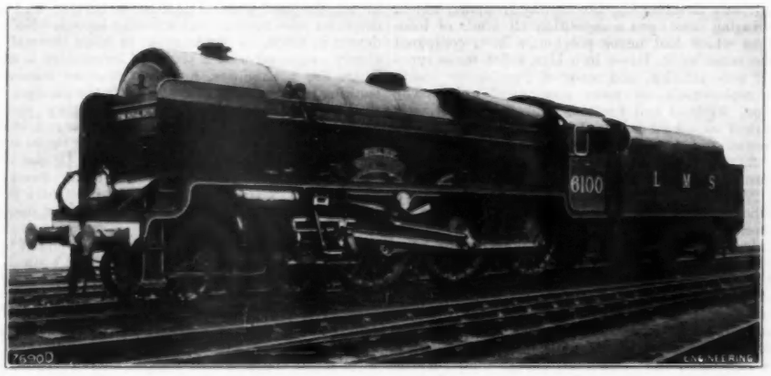


FIG. 4.

THE LOCOMOTIVE IN MECHANICAL ENGINEERING.*

By W. A. STANIER, M.I.Mech.E.

LOCOMOTIVE engineers played no small part in the foundation of the Institution of Mechanical Engineers. Its first president, George Stephenson, the father of locomotive engineering, and his brilliant son Robert, associated with John Ramsbottom, Charles Beyer, James E. McConnell, Matthew Kirtley, of Derby, Richard Peacock, of Manchester, and Alex Allan, of Crewe, were all concerned with its foundation; but it will indicate the wide scope of mechanical engineering to say that there was, after John Ramsbottom, 1870, an interval of 28 years before Samuel Johnson of Derby became president. During the history of the Institution 11 locomotive engineers have had the distinction and honour of occupying the chair founded by George Stephenson in 1847.

When I commenced my training in January, 1892, locomotive practice on the Great Western, under the guidance of William Dean, was very much the same as that of other railways of the time. The locomotives were comparatively small, with steam pressures up to 140 lb. per square inch, but very quickly another phase began; steam pressures were raised to 160 lb. per square inch and a bogie became necessary in front to provide a lengthened wheelbase on which to carry the larger boilers. About 1902, Churchward brought out the first big departure from current practice, when he built six-wheel coupled express passenger engines with cylinders having 30-in. stroke and fitted with valve gear having an unusually long travel and a greater lap. These characteristics made it possible to work the engine so that greater advantage was obtained from the expansion of the steam. Churchward continued these features throughout his career as chief mechanical engineer of the Great Western. His practice has been adopted and developed gradually on all the other English railways, and it is the development that has taken place on the railway with which I have been connected for the last 10 years to which I shall principally refer.

The progress of the steam locomotive can be viewed from several aspects, the most obvious being those of size and power. The advance in power has been continuous, but in recent years the limits of allowable size in this country have almost been reached; so increase in power per unit of weight, which is one form of efficiency, has been called for and achieved. In reliability, in lowness of repair costs, and as an effective means of moving traffic, the advance, although less obvious, has been equally steady; but in thermal efficiency—the net return in work done for each unit of heat supplied—it must be admitted that progress has been more halting, and, for reasons which I shall explain, it has lagged behind the advances made in the use of steam in marine and land installations.

By the "fifties" of last century, the details of British locomotive design had become more or less stabilised; largely as a result of the work of John Ramsbottom, who introduced split piston rings of iron, steel, or brass, the screw reversing gear, displacement lubrication, and the water pick-up, which enabled the locomotive to take water from troughs between the rails when running. From that time until the beginning of the present century, almost the sole increase in basic thermal efficiency was that due to an increase in average boiler pressure from 140 lb. to 180 lb. per square inch. The actual efficiency of the engine in running condition continued through all this period to fall far short of the theoretical figure, due to various cylinder losses arising from condensation, throttling, and leakage. There were reasons for this lull in progress. Cheap fuel and the absence of any spur to action from alternative forms of transport did not provide any powerful urge to do better. Scientifically exact means of measurement and comparison had not been developed, while the division of railways into small self-contained units set barriers in the way of interchange of experience. Moreover, in few branches of engineering does the designer live in such close daily contact with his products throughout their working lives as does the railway mechanical engineer. The resulting preoccupation with reliability has tended to provide arguments against breaking away from practice which has been well tried in the past.

This long period of relatively slow progress served to crystallise ideas on design into a definite British school of thought, and however much the engines of the different railways might vary in colour and shape, in the fundamentals affecting their thermal efficiency they were extraordinarily alike. Further, so well established did this school become that it has persisted far into the present century, and numerous examples

* Presidential address on "The Position of the Locomotive in Mechanical Engineering," delivered to the Institution of Mechanical Engineers, in London, on Friday, October 24, 1941. Abridged.

of this basic design are still running to-day. Many of them have been built in recent years concurrently with more efficient types. Simple, reliable, and cheap to maintain, these engines move a considerable proportion of our traffic, and are beloved of the operating departments. There are 3,250 of them on the London, Midland and Scottish Railway alone. Fig. 1, on page 357, shows a typical example.

Apart from isolated instances, the first considerable and lasting break-away from the almost traditional form in this country was, as already stated, the work of Churchward. In pioneer work carried out from 1902 onwards, a gain was made in theoretical efficiency by extending the heat range both upwards, by increasing the boiler pressure to 225 lb. per square inch, and downwards, by reducing the exhaust pressure as a result of improved valve events. The gain in actual efficiency was even more marked, owing to the big cut in cylinder losses—hitherto looked upon as unavoidable—achieved by the use of long-lap valves, and cylinders with direct ports and passages and minimum clearance volume. Churchward had the vision and the courage to combine all these features, some of them borrowed from French and American practice, into a range of simple standard locomotives which were many years ahead of their time (Fig. 2, on page 357). It is interesting to recollect that these improvements were evolved from a consideration of first principles and by intelligent observation of what was going on in the world, and were not the result of scientific testing or research as we now know them. For this reason, among others, little record was made available of the practical steps involved, nor were any test results made known; so the importance of what had been done was not generally realised, and there was a long time lag before the characteristics of Churchward's designs began to find their way on to other railways.

The next notable advance was the introduction of the superheater. Attempts to produce a practical superheater had been made for many years, but the smoke-type design originated by Schmidt in Germany was the first successful application, and between 1908 and 1912 superheating became accepted practice on practically all British railways. The steam temperature of about 600 deg. F. obtainable thereby reduced condensation losses to a negligible quantity, and gave locomotive engineers a present of a 15 per cent. to 20 per cent. drop in actual coal consumption, with no other effort on their part than the application of a relatively simple apparatus. The fullest record of what was done at that time is contained in a paper by Sir Henry Fowler, and in its subsequent discussion.*

Paradoxical as it may appear, this windfall actually had the effect of retarding the further progress in improving thermal efficiency for many years, and led attention away from the fundamentals of Churchward's success. With so much gained from superheating, locomotive engineers were unwilling to believe that anything of much value could be obtained by abandoning their traditional cylinder designs and valve events. Indeed, it was held to be one of the virtues of superheated steam that it could successfully thread its way through tortuous passages and past valves of small diameter. Except for the general adoption of piston valves in place of slide valves, which, with the wide piston rings then in use, did little to reduce steam leakage, no fundamental alteration in cylinder and valve gear design was made. A representative superheated engine of the period is shown in Fig. 3, on page 357.

Churchward, on the other hand, realising that his own designs, with their greatly improved cylinder efficiency, produced results as good as, if not better than, the superheated engines on other lines, contented himself with applying only a low degree of superheat, with steam temperatures in the region of 500 deg. F. Thus the third stage of improvement, that of combining improved cylinder and valve-gear design with steam temperatures of 600 deg. F. or so, was delayed until the period of the last war. Except for a single small class of 4-4-0 engines on the Lancashire and Yorkshire Railway, which combined these features almost by accident in 1908—the true value of which was not appreciated by the owning company—the first engines in this country so built were those of Maunsell's 2-6-0 design of 1917 for the South Eastern and Chatham Railway, followed by the London, Midland and Scottish Railway mixed-traffic engines of the same wheel arrangement in 1926. After that date, these features became fairly general throughout the country for new construction, as exemplified by such well-known locomotives as the later examples of Gresley's "Pacific" engines, Maunsell's Lord Nelson class, and Fowler's Royal Scot. The latter, which appeared in 1927, is illustrated in Fig. 4, page 357. The most recent stage of development has been a general refining of all the above features of design, and their application to the smaller as well as the larger types of engines on the different railways. As examples, I illustrate in Figs. 5 to 8, on this and the opposite pages, four of the standard locomotives on the L.M.S. Railway.

The general advance in the past twenty years has been greatly facilitated by the railway grouping, which, by bringing into open competition all kinds of locomotives which had never previously been compared on the same work, threw into high relief those types which were inferior, and made it possible to justify their replacement by more economical units. The London, Midland and Scottish Railway in particular embarked on a bold policy of breaking up the old and inefficient types of the constituent companies. To-day, 2,000 engines on that line have cylinders of modern design and long-lap valve gear, as against only 25 in 1923. Of the total stock, 56 per cent. is superheated, and the engines working the heaviest Anglo-Scottish services show a reduction of 40 per cent. in coal consumed per drawbar horse-power, compared with those which were the best available in 1926.

Many heroic individual attempts have been made to break away from normal designs, without having a lasting influence. Chief of these have been the continually recurring attempts to adopt compound expansion, offering certain advantages, at least in theory. Only one class, the "Midland" compound, survives to-day. Turbines with condensing plant, and high-pressure water-tube boilers, have been tried in a number of ingenious applications, but none survives in this country at the present time. Indeed, the only "abnormal" locomotive type available for everyday active service is the London, Midland and Scottish "Turbomotive" (Fig. 9, opposite), which substitutes in the simplest possible manner a turbine and gear drive for the normal reciprocating layout. No condenser is fitted, so the increase in basic thermal efficiency compared with a standard locomotive is small. There are possibilities, however, of more economical working at high power outputs, while the purely rotary working parts being totally enclosed may promote lower upkeep costs. This engine has now run 185,700 miles in express service, but data are not yet available for a final summing up of all the results. Of non-steam motive power, the Diesel engine has so far, except for some light railcars, only established itself here in the field of shunting locomotives for intensively operated freight yards.

Such have been the main lines of development in the British locomotive up to the present, and against this background we may proceed to examine its status to-day.

Many factors influence the cost of traction per ton-mile, of which fuel consumption is only one, but thermal efficiency is particularly within the province of the mechanical engineer and I shall, therefore, deal with this aspect first. For one reason and another we have been hitherto without means in this country for the

* "Superheating Steam in Locomotives," *Proc. Inst.C.E.*, vol. 196, page 77 (1913-14).

BRITISH LOCOMOTIVE ENGINEERING.

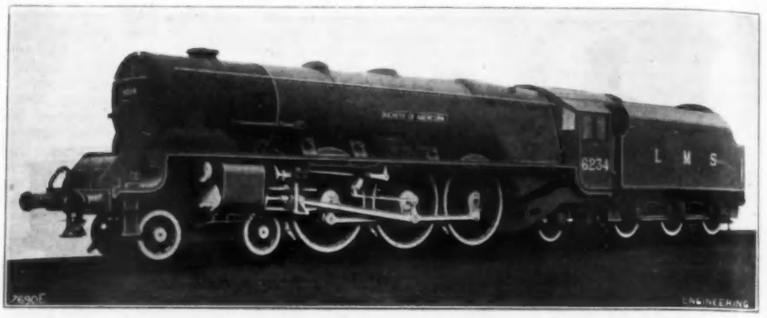


Fig. 5.

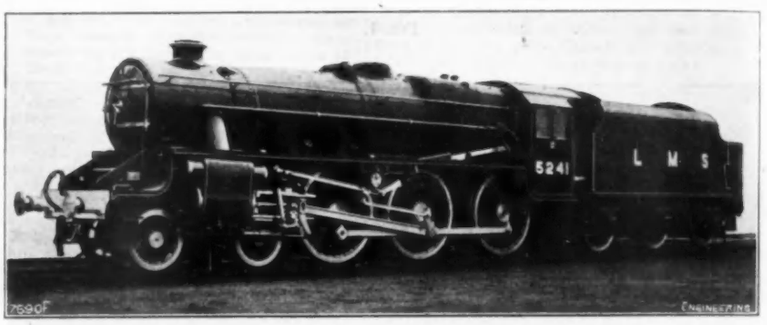


Fig. 6.

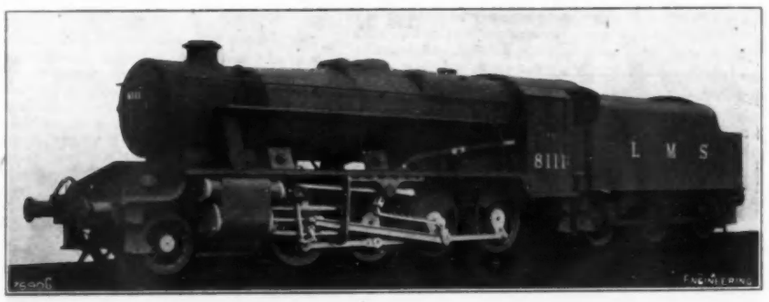


Fig. 7.

BRITISH LOCOMOTIVE ENGINEERING.

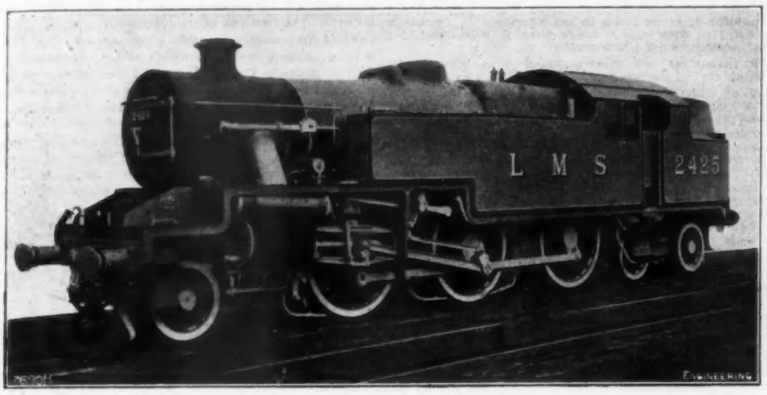


FIG. 8.

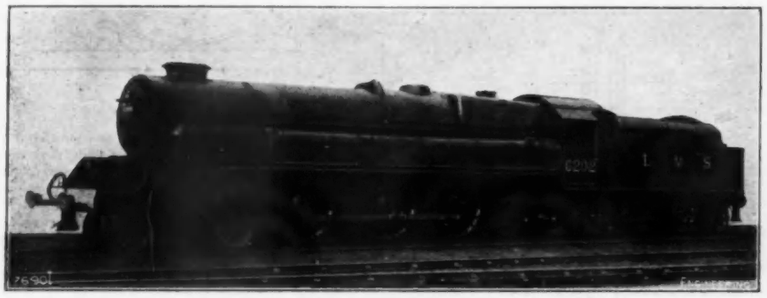


FIG. 9.

TABLE I.—APPROXIMATE BEST THERMAL EFFICIENCIES OF VARIOUS STEAM LOCOMOTIVES.

	Representative Saturated-Steam Locomotive, built *c.* 1880.	Representative Superheated Locomotive, built *c.* 1912.	L.M. & S.R. "Coronation" Superheated 4-6-2 Simple Expansion.	Chapelon Superheated 4-8-0, Compound Expansion.	Advanced Steam Power-Station Practice.*
Working pressure, lb. per sq. in.	160	180	250	295	1,350
Steam temperature, deg. F.	371	580	615	750	950
Heat drop, B.Th.U. per lb. of steam	150·8	187	213·8	253	610
Theoretical efficiency of cycle (Rankine), per cent.	12·8	15·4	17·2	19·7	48
Theoretical steam consumption per i.h.p.-hr., lb.	16·9	13·6	11·9	10·0	—
Actual engine cycle efficiency, per cent.	7·64	9·6	14·2	16·5	38·0†
Estimated steam per i.h.p.-hour, lb.	28·3	22·0	14·5	11·7	—
Ratio of actual efficiency to theoretical efficiency of engine, per cent.	60	62	82	84	79
Boiler efficiency, per cent.	68	75	76	78	90
Overall thermal efficiency of locomotive on i.h.p. basis, per cent.	5·2	7·2	10·8	12·8	34·2‡

* Based on particulars given in Sir Leonard Pearce's Thomas Hawksley Lecture, *Proc.I.Mech.E.*, vol. 142, page 305 (1939).
† Overall efficiency based on units generated, *i.e.*, including factor for efficiency of generator.
‡ Efficiency at motor shaft, corresponding as nearly as possible to efficiency in cylinder of direct-drive steam locomotive, *i.e.*, minus the final drive in each case.

TABLE II.—PARTICULARS OF REPRESENTATIVE LOCOMOTIVE BOILERS (L.M. AND S. RAILWAY).

	4-6-2 "Coronation."	4-6-0 Mixed-Traffic.	2-6-4 Tank Engine.	4-4-0 Compound.	0-6-0 Standard Freight.
Working pressure, lb. per sq. in.	250	225	200	200	175
Maximum barrel diameter	6 ft. 5⅛ in.	5 ft. 8½ in.	5 ft. 3 in.	4 ft. 9½ in.	4 ft. 9½ in.
Length between tube plates	19 ft. 3 in.	13 ft. 3 in.	12 ft. 3 in.	12 ft. 3 in.	10 ft. 10½ in.
Length of firebox	8 ft. 6 in.	9 ft. 2⅛ in.	8 ft. 6 in.	9 ft. 0 in.	7 ft. 0 in.
Evaporative heating surface, sq. ft.—					
Tubes	2,577·0	1,478·7	1,223·0	1,109·7	1,033·7
Firebox	230·5	171·3	143·0	147·3	123·8
Total	2,807·5	1,650·0	1,366·0	1,317·0	1,157·5
Superheated surface, sq. ft.	856	359·3	245	291	253
Grate area, sq. ft.	50	28·65	26·7	28·4	21·1
Free area—					
Small tubes, sq. ft.	3·23	2·22	2·04	1·89	1·89
Large tubes, sq. ft.	3·66	2·54	1·89	1·58	1·58
Total, sq. ft.	6·89	4·74	3·93	3·47	3·47
Total free area through tubes as percentage of grate area	13·8	16·54	14·7	12·2	16·5
Weight of boiler empty (fully mounted)	t. c. q. 28 3 2	t. c. q. 17 16 2	t. c. q. 14 2 3	t. c. q. 15 16 2	t. c. q. 13 7 0
Approximate steam production, lb. per hour	33,000	20,000	17,000	17,000	14,000

scientific testing of locomotives. Comparative testing there has been in plenty, but because the locomotive travels over an undulating track and within severe restrictions of space and weight, and, moreover, since its operating conditions call for continual variation in speed and load, it has been much more difficult than in land or marine work to isolate all the variables, and to obtain absolute test figures for the amount of heat turned into useful work in the cylinders. We do not yet know definitely the actual efficiencies we attain. It is necessary, therefore, to estimate them, but this can be done with some degree of probability from tests at variable speed on the road. These road-test figures can be supplemented by data provided by constant-speed testing on the line and on stationary test plants abroad.

Table I, on this page, attempts to set out the relative thermal efficiencies for different stages in the development of steam motive power, showing first of all the basic theoretical efficiency of the cycle, then the actual engine and boiler efficiencies, and finally an over-all thermal efficiency for the plant as a whole on a basis of indicated horse-power. The first column represents a saturated steam engine as designed in the last century (of which many are still running); col. 2 represents a superheated design of the period 1908-12, still retaining old-fashioned cylinder and valve-gear design; col. 3 shows the position of representative best present-day design in this country; while col. 4 is illustrative of the work done by Chapelon in France, and represents very nearly the best which can be expected from further refinement in the normal reciprocating locomotive. The last column gives comparative figures for an "ideal" application of the most advanced power-station practice to the locomotive, leaving on one side the question of how far the various features of power-station practice could in fact be applied. The record of the locomotive is not, as is sometimes thought, entirely bad, and Table I shows clearly where it has advanced and where it still falls short.

Thermally, the boiler is the most satisfactory part. The high heat-absorption rate of the water-enclosed inner firebox, and the rapid heat transfer arising from high gas speeds along the tubes, combine to produce a high heating-surface efficiency which does not drop appreciably at the maximum output of which the boiler is capable. The principal loss is that due to fuel being drawn off the firebed by the fierceness of the draught and expelled unburned from the tubes at high output of power. The overall efficiency exceeds 80 per cent. at low rates of combustion and falls along a practically straight line to about 50 per cent. when the boiler is forced to the limit of its output, which corresponds to about 200 lb. of coal per square foot of grate per hour. Boilers which are proportioned to work at an average firing rate of 50 lb. to 60 lb. per square foot of grate per hour are capable of maintaining efficiencies in the region of 75 per cent., a figure which bears comparison with other types. The efficiency cited holds good for a wide variety of individual designs, and this type of boiler has also further solid advantages. It follows varying demands with great rapidity, having a considerable thermal storage capacity in the large quantity of water carried. It is capable of severe overload and is not too sensitive to the quality of the water, while its weight and size are very moderate in relation to the output. Its cylindrical body possesses considerable rigidity and strength. Table II, on this page, gives particulars of some representative boilers.

Without condensing, the thermal gains due to increasing the working pressure are only obtained at a diminishing rate, and beyond about 300 lb. per square inch the gain due to successive increments in pressure falls away rapidly. Since it is possible to design a normal locomotive-type boiler for such a pressure, there is, therefore, little urge or justification for departing from the conventional type merely to secure thermal gains, and alternative water-tube designs are attractive only as a possible means of eliminating stays, to assist mechanical maintenance. They become of real interest as higher working pressures are envisaged in conjunction with condensing.

A careful distinction must be made in considering engine efficiency. As Table I has shown, the theoretical thermal efficiency even to-day lags far behind that of the power station, but this is largely due to the difficulties of finding space for the essential features of high pressure turbo-condensing design as well as in the accompanying weight restrictions. Thus, in basic efficiency, it is physical limitations which have offered obstacles to progress. In utilisation of the available theoretical efficiency, on the other hand, the locomotive has a very good record of progress, and the best modern designs are capable of realising in the cylinders as much as 84 per cent. of the utmost that theory allows.

As against this, a large number of the older engines still running do not achieve more than 60 per cent. in this respect, due to severe cylinder losses. These consist of condensation, internal leakage past valves and pistons, throttling of the steam due to insufficient port and passage areas, and high back pressure due to restricted exhaust events. Such losses have been greatly reduced by superheating, by the introduction of valves and pistons having numerous narrow rings, by improved lubrication, and long-lap valve gear. More recently, the work of Chapelon in France has underlined the importance of sufficient area of valves,

ports, and passages, and the benefit of streamlining them internally as far as possible, to reduce resistance to the flow of steam; and modern cylinder designs have been still further improved in this respect. All the last-mentioned improvements are applicable to the normal simple-expansion engine, and, at the outbreak of war, designs were on the board for a modified Coronation engine, to carry 300 lb. per square inch boiler pressure and a steam temperature of 750 deg. F., embodying the main results of Chapelon's investigations but without making use of compound expansion.

(To be continued.)

PRECAUTIONS IN USING RADIUM PAINT.

The manufacture and application of radioactive luminous compounds, otherwise known as "luminous material" or "radium paint" and consisting of a mixture of phosphorescent zinc sulphide and radium mesothorium, or other radioactive substance, expose the technicians and painters engaged in this work to certain risks, and in the early days of the industry cases of severe "radium poisoning" occurred. A number of investigations were held, as a result of which the causes of radium poisoning were made clear and protective measures indicated. That these protective measures have been effective is shown by the fact that no new cases of injury among workers in this field have come to light in recent years. Latterly there has been an increasing demand for luminous markings on dials and other equipment, mainly for apparatus for the Services, and this has necessitated extensions at dial-painting shops, and in some works, the opening of entirely new shops. Many additional employees have therefore been brought into the industry recently and for this reason firms connected with the dial-painting industry in the United States have requested the National Bureau of Standards to issue a handbook* explaining the safe methods of handling the luminous compounds. This will be of interest to firms engaged on similar work in this country.

At the outset, the committee responsible has classified, under three main heads, the known risks involved in the handling of radium paints. First in order of importance is placed the risk of inhalation of solid radioactive luminous compounds; this has been the cause of the most serious injuries in the past. The risk placed second in importance is that of inhaling the radon or thoron liberated from the compound into the air, and the third, that of exposing the whole body to gamma radiation from the compound. It is stated that experience during the last 15 years has shown that when due precautions are taken to prevent the compound entering the mouth or lungs of workers, no detectable injury has resulted. It is recommended, however that workers should be tested periodically for radon exhaled in the breath. By this test small amounts of radium can be detected long before clinical symptoms have appeared. If evidence of the presence of more than 0·1 microgramme of radium is revealed in any employee by the expired-air test, he should change his occupation immediately and be subjected to decalcification therapy or other suitable treatment. The continued inhalation of radon or thoron may have serious effects on the lungs and may also be a contributing factor in the anæmia resulting from radium poisoning. To combat this danger, the radon concentration in the atmosphere of workrooms should not exceed 10^{-11} curie per litre. With regard to the third risk, it is laid down that the exposure of the employee to gamma radiation shall not exceed 0·1 röntgen per day.

The situation may be summed up by stating that, in the main, the essential requirements are neatness and orderliness in the workshop. All workrooms and other places used by the employees must be ventilated in such a manner as to maintain the radon concentration in the atmosphere well below the danger limit. Should accidental spilling of the paint occur all traces of it should be cleaned up immediately. The gamma-ray exposure can be controlled by permitting only small amounts of the compound, either before or after application, to be present in the workrooms, and by storing the material in a lead-lined cabinet situated as far away as possible from the staff. At the end of a working period, the employees must wash their hands in a solvent capable of removing the particular adhesive used in making up the radium paint. Moreover, before leaving the workroom, the hands and clothing of the personnel should be inspected to ascertain whether they are free from the compound, and a convenient method of doing this is to view them in a room in which the only light provided is from an argon lamp.

* *Safe Handling of Radioactive Luminous Compound*, National Bureau of Standards Handbook, No. H 27 United States Government Printing Office, Washington.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

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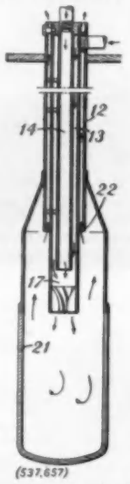
FURNACE APPARATUS.

537,657. Metal-Melting Furnace Heater. Gibbons Brothers, Limited, of Dudley, M. van Marle and A. W. Ogilvy-Webb, of Dudley. (7 *Figs.*) December 27, 1939.—The invention is a gas or oil-fired heating element or radiant for furnaces, particularly those employed for the heat treatment of metal, the arrangement being such as to provide for the concentration of heat at the end of the element. The radiant element consists of an outer tube 12, intermediate tube 13 and inner tube 14, all three of which are arranged concentrically and spaced apart. The lower end of the inner tube 14 is open, and the lower



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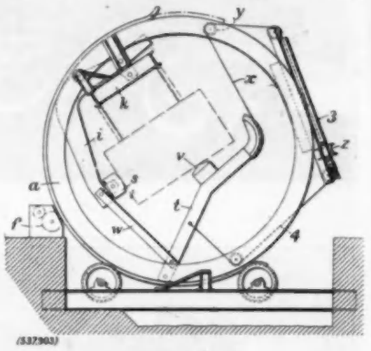
end of the intermediate tube extends below it to form a mixing chamber 17. The lower part of the outer tube is attached to a bulb 21. The lower part 22 of the outer tube 12 extends into the bulb and forms an annular baffle for the products of combustion, gas or vaporised oil being fed to one of the tubes 13 or 14 and air to the other. The air and the gas or vaporised oil are received by the mixing chamber from the inner and intermediate tubes, and pass from the mixing chamber into the combustion chamber within the bulb 21. Combustion is thus concentrated at one end of the element, and the products of combustion pass away through the annular space between the outer and intermediate tubes 12 and 13. (*Accepted July* 1, 1941.)

RAILWAYS AND TRAMWAYS.

537,903. Rotary Tippler for Coal Wagons. New Conveyor Company, Limited, of Oldbury, and W. C. Murray, of Oldbury. (4 *Figs.*) April 9, 1940.—The tippler frame *a* is supported on rollers and is rotated by gearing *f* engaging toothed segments on the end rings of the frame. Within the frame is mounted a lever *i* constructed from a pair of similar interconnected parts close to the end rings of the frame and operating as a single lever. The free end lies close to one side of the wagon. The other end of the lever *i* is pivoted to the frame to one side of the central vertical plane of the wagon when the tippler is in its initial position. Above the pivoted portion of the lever is a horizontal platform *k* with rails for the wagon wheels. This platform is pivoted to the lever at points vertically above the pivots connecting the lever *i* with the frame and is steadied when in its lowest position. At or near the free end of the lever *i* is pivoted a lateral abutment *s* against which one side of the wagon can bear when the tippler is in action, and the face of the abutment which makes contact with the side of the wagon is rounded to afford a rolling contact. In the upper part of the tippler frame there is another lever *t*. This, like the lever *i*, is constructed from a pair of similar interconnected parts adjacent to opposite end rings of the frame, and pivoted at one end to the frame by coaxial pivots. The lever *t* extends across the top of the wagon and carries a longitudinal clamping bar *v*. Adjacent to its pivot axis the lever *t* is connected by parallel links *w* to the free end of the lever *i*. The free end of the lever *t* carrying the clamping bar *v* is connected by a cable *x* passing over guide pulleys *y* to a balance weight *z* which slides between guides 3 on the frame. The other end of the balance weight is attached by a cable 4 to the lever *t* at a position between the clamping bar *v* and the pivot axis of the lever. The operation of the tippler is as follows: After the loaded wagon has been placed on the platform *k* the tippler is set in motion. The first effect of the rotation of the tippler is to free the platform, thus allowing it to tilt about its pivots. The tilting of the platform brings one



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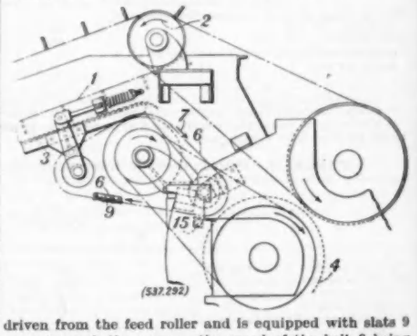
side of the wagon into contact with the abutment *s* and turns the lever *i* about its pivots. This movement is transmitted through the links *w* to the lever *t*, bringing the clamping bar *v* into contact with the top of the wagon and securing it to the platform *k*. Movement of the lever *t* is accompanied by a corresponding movement of the balance weight *z*. As the rotation of the tippler continues, the balance weight *z* increases the clamping action of the bar *v* on the wagon. When the frame *a* reaches the discharging position shown, the clamping action is exerted mainly by the weight *z*. After discharge, the tippler is returned to its initial position and the balance weight raises the clamping bar *v* clear of the wagon. The wagon can then be moved out of the tippler. (*Accepted July* 11, 1941.)

MISCELLANEOUS.

537,292. Sugar-Cane Crushing Mill. The Mirrlees Watson Company, Limited, of Glasgow, and C. B. B. Connel, of St. Kitts. (1 *Fig.*) September 15, 1939.—The invention is applicable to sugar-cane crushing mills of the type including a feed roller and a conveyor or chute for conveying megass to the feed roller. The conveyor 1 circulates in the direction of the arrow 2 in a trough 3. The roller 4 of the mill rollers is the feed roller. Megass is delivered by the conveyor 1 to a belt 6 travelling in the direction of the arrow 7 between the conveyor and the feed roller. The belt 6 is friction



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driven from the feed roller and is equipped with slats 9 so as to push the megass, the speed of the belt 6 being higher than the peripheral speed of the feed roller. A perforated steam pipe 15 is arranged so that the steam impinges on the slats and serves to clear them and to destroy any bacteria. Since the surface speed of the moving belt 6 is higher than the peripheral speed of the mill rollers, matting or felting of the megass is promoted at the point of delivery on to the feed roller, and it is found that the fibre particles of the felted megass do not interfere with the free drainage of the expressed juice and materially assist the rollers in taking the feed, the blanket being unbroken and not liable to rupture by the flow of juice in the direction opposite to the direction of travel of the megass. (*Accepted June* 17, 1941.)